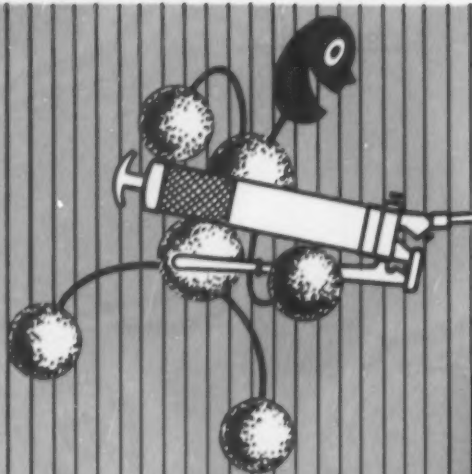


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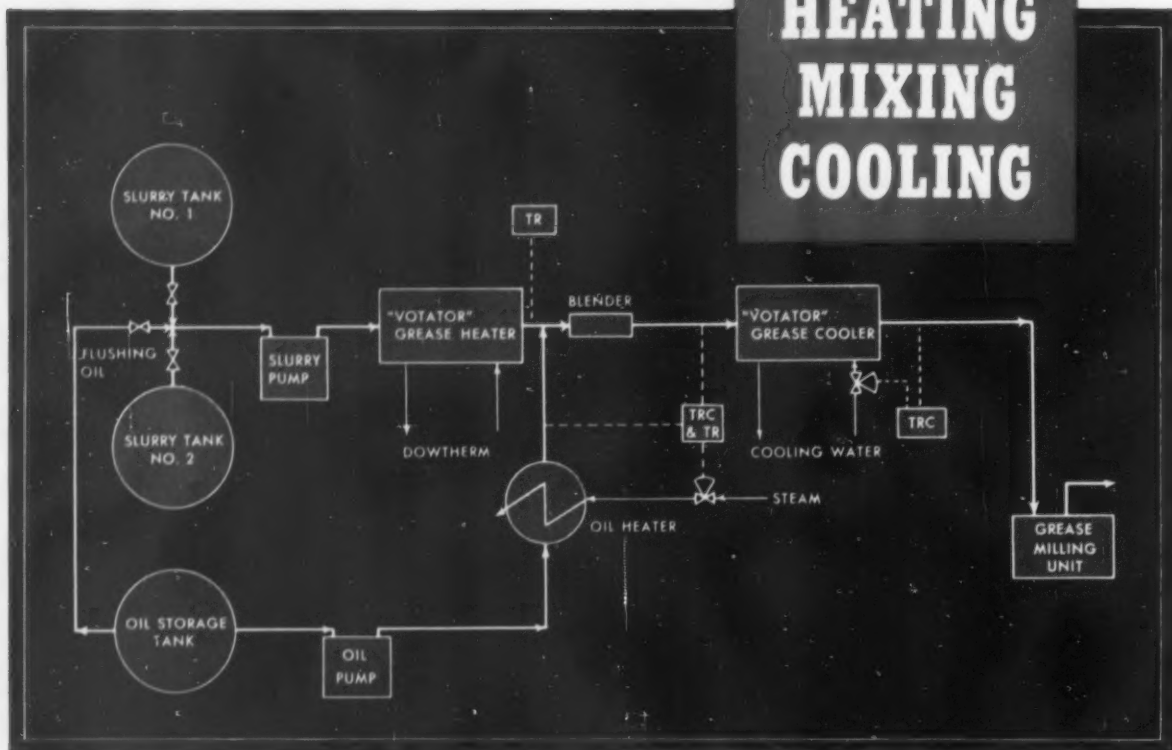
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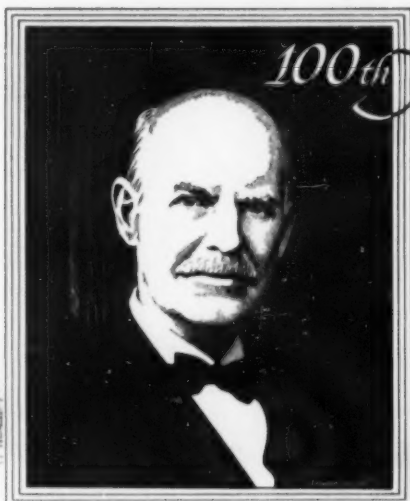
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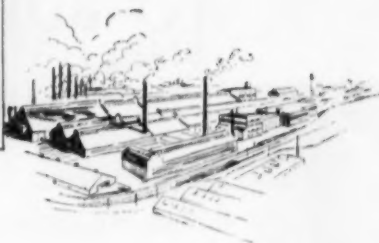
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100th Anniversary

INVENTOR
SCIENTIST
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this was genius...

EDWARD GOODRICH ACHESON

Yes, this was genius.

Thomas A. Edison knew it. In paying tribute upon the occasion of Doctor Acheson's passing, he said "...as a former associate I know the world loves a great genius."

Leo Hendrik Baekeland knew it. He remembered him "as a man who combined a most fertile brain with great strength of conviction."

Walter B. Pitkin knew it. This famous psychologist said "As he created his place in our civilization so does that place pass with him. None shall fill it."

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But what makes genius?

Employing a mixture of carbon, sand, salt, and sawdust in a simple but effective electric furnace, made up of a few strands of wire, a carbon rod, and a plumber's bowl, Edward Goodrich Acheson was able to bring into being a mass of scintillating crystals rivaling many gems in splendor and almost matching the diamond in hardness. These highly abrasive crystals he crushed and made into grinding wheels, and these wheels, in turn, were used to shape metals and make machines. Called "Carborundum" by Acheson and silicon carbide by the chemist, this new material did its job so well that it is credited with making possible today the mass production of automobiles, tractors, and countless other mechanisms.

Possibly silicon carbide could be made better—harder or sharper. To this end Acheson subjected silicon carbide to higher temperatures for longer periods; what he obtained was not a harder substance but, instead, one of the softest—pure graphite. The extreme conditions to which he had exposed his jewels of industry brought about their disintegration, the

silicon passing off as vapor and the carbon remaining as a soft, unctuous residue. Manufactured graphite, destined to be of far-reaching importance, became another of Acheson's contributions to industry.

Unquenchable curiosity, coupled with the indomitable spirit that was his, led him to uncover means of preparing this new product of the electric furnace in the form of plates and cylinders. Put to work as electrodes, these soon revolutionized electrochemical and electrometallurgical operations. Acheson had now made commercially feasible the production of new families of chemicals and laid the groundwork for the present efficient manufacture of steel and alloys.

During Acheson's painstaking efforts to produce graphite crucibles he experimented with many clays for use as binding agents—and he learned much about them—so much in fact that he was able to explain why the ancient Egyptians used straw in their brick making and what caused the formation of the deltas of the Nile and Mississippi. Most important, he discovered a method of rendering graphite colloidal.

Colloidal graphite in modern industry plays a role that is varied and complex, its unique properties finding utility in such dissimilar fields as lubrication, electronics, metalworking, and lithography, to name a few. The techniques originated by Acheson for colloiddally dispersing graphite are being applied to other solids including carbon blacks, pigments, and minerals.

To those of us in the companies identified with Doctor Acheson, his perseverance and achievement are an inspiration. We are proud to offer this tribute to his genius on the 100th anniversary of his birth.

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President's page

by W. M. MURRAY, President, NLGI

TO BUILD WELL



We speak of "commercialism" as tainting sports, and we hear of places and establishments considered as being too commercial for good taste. Such uses are not fair to the word commerce. It is really a pleasant thing to be literally wrapped-up in the commercialism of one's work. We in NLGI are commercial and as individuals we vie in business to make commercial progress.

Apart from association for business reasons, we cultivate friendship of our fellows because such friendship makes the path of good business very pleasant and less difficult to follow.

It is easier for me to think of and to consider Bill, Art, George, and the so many others of the earlier element, as fast friends rather than as business competitors, although, really they are just as great in competition as they are in friendship. Instead of styling the association "commercialized friendship" it is most realistic to call it "friendly commerce."

We have honorary members now which is a sign of association maturity and of stability. Members who have retired are just as loyal to business and to friendships as they were during the formulating years when dates and ages were both in the thirties. Many of the presently young men group are, of course, just as friendly as the predecessor group. The younger group become "we" to themselves and we to them are "they," the passing generation of "old timers." How true it is that the boy becomes the father of the man. We have two things to sponsor with respect to the preceding sentences; the development of the younger members of the Institute toward the leadership of which they are capable, and a continuous pattern for real, albeit friendly competition. Let us be energetically commercial about it!

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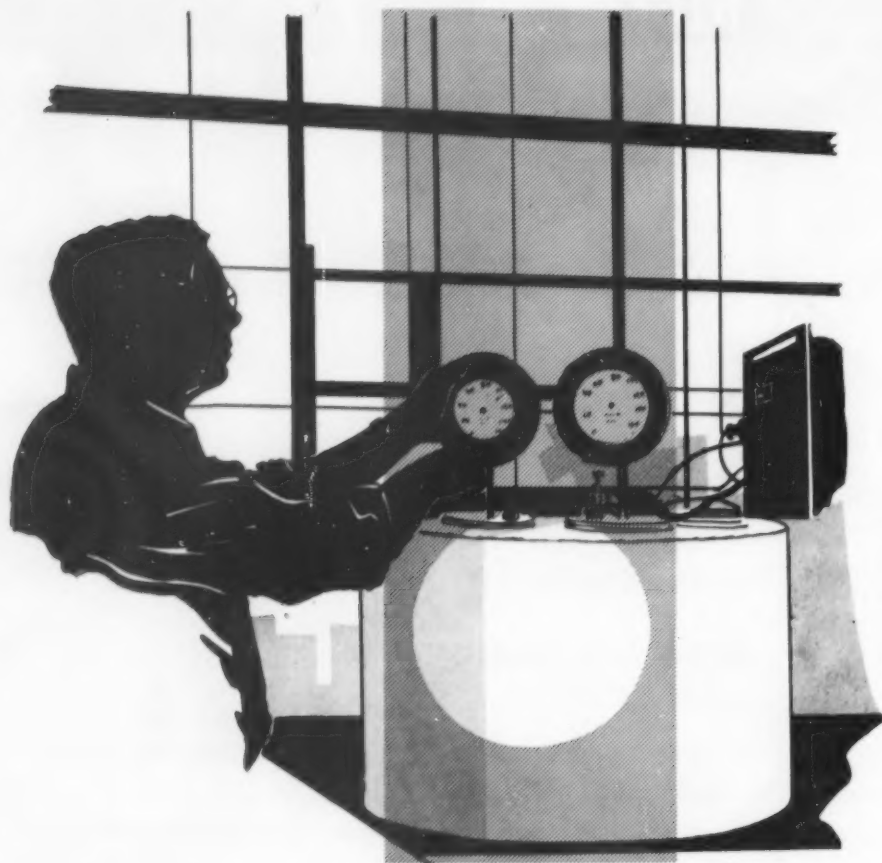
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ABOUT THE COVER

ANTIOXIDANTS FOR GREASES, appearing on page 8, is the subject of this month's cover. It is a study of additives which will inhibit grease oxidation to determine which additives can be effective under high temperature over extended periods of time.

Artist Ronald Jones combines the high temperature reading, the clock and six black blocks to illustrate the point that temperature and time have decided effect and only six inhibitors were able to function as long as 500 hours at 250 F.



Antioxidants for Greases

By S. FRED CALHOUN
Rock Island Arsenal

SYNOPSIS

The opinions or assertions contained herein are not to be construed as being official or reflecting the views of the Department of the Army.

The practice of the Armed Services in stockpiling greases for extended periods of time, under various storage conditions, and of storing vehicles in a lubricated ready for action condition, has made it more imperative that the greases be able to withstand the deterioration caused by oxidation. It is also becoming more common to provide motors and other machines with lubricated-for-life bearings. These machines often have to operate for long periods at elevated temperatures or to operate intermittently over extended periods of time. Industry as well as the Armed Services have many examples of such conditions.

At present it seems most practical to use some additive in the grease to inhibit this oxidation. Several such additives are in constant use by grease makers. It was desired to make a comparative study of those inhibitors in use as well as to develop additional ones with a view of raising the temperature range for which they were effective.

A total of 69 different compounds or formulations have been examined for their inhibiting ability in a variety of grease types

and in several concentrations. Oxidations were run at 210 F and 250 F and the results tabulated. Acid and base numbers and copper corrosions were also determined for all greases containing inhibitors which showed any promise. Graphs showing the different types of oxidation curves obtained are included.

There is apparently no single structural or physical property of the compound which can be used to foretell its inhibiting ability. The ability to inhibit oxidation apparently is a function of the compound itself or the type of grease in which it is used. Temperature had a decided effect upon oxidation and only six inhibitors were able to function for as long as 500 hours at 250 F.

The most successful class of inhibitors were the amines, either singly or in mixtures. Worthy of special note are the phenylenediamines. Several organo sulfur compounds, organo phosphorous compounds and phenolic derivatives proved to be efficient inhibitors and should be considered because of possible antiwear properties. A few compounds of a miscellaneous type were tried but failed to show anything of interest.

Antioxidants for Greases

The protection of a lubricant against the deleterious effects of atmospheric oxygen is rapidly becoming a major problem. Present day mechanisms are required to run for longer periods of time, at higher speeds, and at higher temperatures than formerly. It is not uncommon for modern machines, especially electric motors, to be equipped with "lubricated for life" ball or roller bearings. In many cases such machines must operate under higher than normal temperatures for long periods of time either continuously or intermittently. Instances of such conditions are found in metal fabricating mills, in glass manufacturing and in plastics molding plants. The armed forces have similar conditions in jet engines, in radar installations and in many others. They are also faced with an additional problem. Large quantities of various types of equipment are stored in a ready for immediate use condition. Lubricants used must withstand attack by atmospheric oxygen under varied conditions for extended periods of time. This is essentially a problem of static storage, and arises also in any attempt to stockpile lubricants in their original containers. Since both of these practices are a regular part of the program the Armed Services have a definite interest in inhibiting lubricants against oxidation.

Because of their ease of application and ability to stay in place, greases are often the best type of lubricant for a particular use. The problem then is how best to protect a grease against oxidation. So far the most practical approach to the problem has been an inhibitor incorporated in the grease. The literature and patent files¹ list a large number of compounds which have an inhibiting effect upon the oxidation of oils but are somewhat barren in respect to greases. Boner, in his book,² gives a thorough

and comprehensive survey of the literature on this subject.

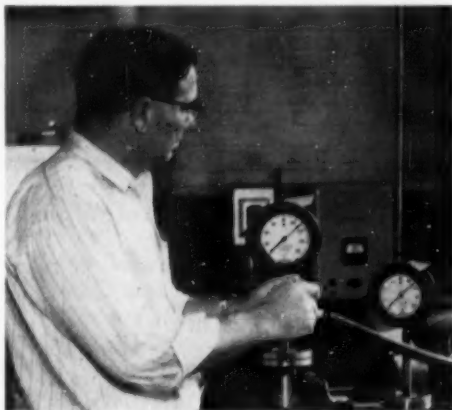
Some of the earliest stabilizers used for greases were the natural inhibitors found in petroleum. Osher³ mentions using an extraction from the sludge formed by sulfuric acid refining of lubricating oils as an inhibitor for greases. It was no doubt an organo sulfur compound. Phenolic derivatives⁴ and amines^{5,6,7} were soon utilized and found quite effective. Many patents have been issued for amine type antioxidants.^{8,9,10} They have been found quite effective and reliable for both oils and greases and new ones are being developed continuously.¹¹

The organo sulfur compounds have continued to be used as antioxidants and new evidence¹² and patents¹³ are continually appearing concerning their use in both oils and greases. Other groups or types of compounds which have received considerable attention as possible antioxidants during the past few years are the organo phosphorous compounds¹⁴ and the metal salts of organic compounds such as amines, phenols,^{15,16,17} and thiocarbamates.^{18,19}

Three other discoveries of substances with interesting possibilities as inhibitors have been reported. Pure carbon of a specified particle size and pH was found to act as an antioxidant for greases.²⁰ It was also discovered that ion exchange resins of the carboxylic acid type will stabilize a grease against oxidation.²¹ Another group of compounds which have been the object of study by the Naval Research Laboratories are the organo silicon compounds.²² Since they are themselves inert and seem to work well in many types of greases they present promising possibilities. Their inhibiting action is unusual in that it is nonexistent without the presence of the soap which is normally an oxidation catalyst.

Compounds which have thus far shown ability to stabilize a grease against oxidation may be divided into the following groups:

1. Amines
2. Substituted phenols
3. Organo Sulfur compounds
4. Organo phosphorous compounds
5. Organo silicon compounds
6. Metallic salts of organic compounds
7. Organic selenides or tellurides



The author admitting oxygen to a bomb

MacDonald and Dreher²³ report that they have found the organic selenides or tellurides to be the most outstanding of the antioxidants and to impart better bearing performance to the grease. They claim that this outstanding performance is not disclosed in the Norma Hoffman oxidations, but in bearing performance tests.

Since mineral oil constitutes the major portion of a grease it is reasonable to expect an inhibitor that protects the oil would also protect the grease against oxidation. This is true in many cases. There are present in a grease,

however, other components which complicate the oxidation problem. The thickener or gelling agent used may have an adverse effect upon oxidation, metallic soaps are oxidation catalysts. Thus an inhibitor may function in one type of grease and fail to protect another. If the soaps are made in situ by reacting a metallic hydroxide with either a fatty acid or a glyceride, by-products of water and/or glycerine may remain in the finished grease. Both have been shown to accelerate oxidation.³ The presence of unsaturates in the fatty acid or glyceride would also tend to make the product more susceptible to oxidations. The metallic hydroxide itself may contain traces of other metals such as iron, manganese or copper. These metals or their salts will in many cases accelerate oxidation.

The type of oil used and its degree of refinement may itself have a profound effect upon the oxidation stability of the grease. Many investigators have shown that a highly refined oil tends to form the most stable grease.^{2,23,24} Most workers agree, however, that this refinement can be carried too far and that the natural inhibitors present may be removed. Several investigators have concluded that the stability of an oil does not depend so much upon the structure of its components as it does upon the presence of natural inhibitors, probably sulfur compounds, which are present.^{23,26}

Investigations have also shown that oils vary in catalytic susceptibility²⁷ and that metal particles, or salts such as the halides of iron, are quite active catalysts. Soluble lead and copper salts are often active catalysts and could easily be present as the result of wear or chemical corrosion of bearings. It is thus possible for a grease to prove very stable by Norma Hoffman tests and to fail badly in certain uses due to the presence of these metal particles or salts as the result of normal wear or corrosion. It thus behooves the user or manufacturer of a grease to thoroughly test each antioxidant in a particular grease and to retest whenever a new source, or a new batch, of ingredients is used.

An attempt was made in this work to eliminate or equalize as many variables as possible. The mineral oil used was a solvent refined, close cut 80 sec. oil from Mid-continent crudes. It came from the same batch and in sufficient quantity for all work contemplated. The esters varied however and were either commercial products used as received from the manufacturer, or were highly purified mono esters prepared in this laboratory under another project. The lithium soap used was a preformed lithium stearate from a commercial supplier and was of the same batch and in a single container. The lime, lithium hydroxide and fatty acids used in making the mixed soap and calcium soap greases were likewise kept uniform by securing a sufficient supply from a single source and keeping each of them in individual containers. In this way it was planned to avoid any variations caused by products of different suppliers, or different batches from the same supplier, having slightly varying compositions. No attempt was made to determine the purity of any product used. They represented the best obtainable from commercial sources.

The manufacturing processes were also kept as uniform as possible. The lithium soap mineral oil greases

were made by heating the preformed lithium stearate in the mineral oil until solution took place. The antioxidant was added at the beginning of the heating. At first a measurement of temperature at solution was made but this was later abandoned as it was found to vary no more than a few degrees. For the lithium soap mineral oil greases the soap content was fixed at 8%. The final product was worked in a mill arranged so that the grease was forced through a 100 mesh stainless steel gauze. The standard working was twenty passes through the gauze. This usually resulted in a smooth buttery grease.

The lithium soap-ester greases were made in the same manner as the mineral oil greases. It was necessary in some cases to increase the soap content in order to obtain a grease of the proper consistency.

The mixed lithium-calcium soap greases were made by forming the soap in situ. This more nearly duplicated commercial methods. It was planned to have a finished product of approximately 10% soap content. The calculated amount of fatty acids and alkali was mixed and heated with 40% of the oil. The fatty acids were proportioned so as to contain about 70% of 12 hydroxystearic and the alkali adjusted to give 6% of the total weight of soap as calcium soap. The oil-acid-alkali mixture was heated in a stainless steel beaker and stirred continuously by a motor driven stirrer. The temperature was held at 330-350 F until the reaction was complete and then raised to 375 F and the bulk of the remaining oil added. The heat was then turned off and the stirring continued. When the temperature had reached 250 F the additive, dissolved in a small amount of the oil, was added. The stirring was continued until the temperature had fallen to 170-180 F. The product was then milled by giving it one pass through a Morehouse mill with the plates set at 0.001 inch clearance.

The calcium soap greases were made up to calculated 12% of soap. The weighed amount of stearic acid was heated with half the oil to a temperature of 150 F. The dry lime was then added and the temperature raised to 220-30 F and held at this point for two hours. The mixture was allowed to cool to 200 F and 5 grams of water added in small increments. The temperature was allowed to rise to 230-40 F during the adding of the water. The temperature was held at this point until evolution of steam had ceased as evidenced by cessation of bubbling. The temperature was then raised to 260-80 F and held until a sample of the mixture gelled on cooling. The remainder of the oil, containing the additive, was then added and the temperature maintained at 230-40 F until a sample of the mixture would gell on cooling. The product was then chilled rapidly and milled. The product was often a little soft at this point but usually set up on standing a few hours.

The alkalinity or acidity was determined by titrating a benzene-ethyl alcohol-water solutions of the grease to the phenolphthalein endpoint with a standard aqueous solution of KOH or HCl.

The 210 F oxidations were run according to ASTM Method D942-50. They were run for at least 500 hours unless the pressure drop had exceeded 30 pounds previous to this point. In some cases this time was extended when there was no call for the oxidation equipment.

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The copper corrosion tests were run by VVL-791E Method 5314. Dark stains on the copper strip or in the grease, pitting of the copper, or any green coloration on it or in the grease were cause for failure.

The 250 F oxidations were run in the same manner as the 210 F except that an aluminum block heater was used instead of the oil bath. The aluminum block heater was constructed locally and was used as an air bath. It was built with the idea of eventually running tests at 300 F or higher which might be above the safe range of an oil bath. The block was able to hold a preset temperature within ± 1 F. The heater and controls are shown in Figure 1 during the progress of a test.

All greases were kept for a period of several months to observe any possible deleterious effect of the additive such as bleeding, softening or photo affects. There was some bleeding among the softer greases especially the ester fluid types. No softening was noticed. There was some change in color on exposure to light but this was slight and was not deemed detrimental.

Since the object of this study was to compare presently antioxidants as well as develop new ones, several well known inhibitors currently used in greases were studied. The materials used consisted of a variety of compounds and mixtures obtained from the following sources:

1. Synthesized in this laboratory
2. From regular chemical supply houses
3. From firms dealing in petroleum or rubber chemicals
4. Synthesized for this laboratory by the Augustana Research Foundation
5. Miscellaneous suppliers of special chemicals

No attempt was made to further purify any of the inhibitors. They were used as obtained from the supplier. Those synthesized in this laboratory were as pure as could be obtained without resorting to special means of purification.

The results of this study are summarized in Table I. In this table are included the name or description of the



Figure 1—Aluminum Block Heater for Norma Hoffman Oxidations

antioxidant, the percentage used, the type of grease, its penetration, chemical reaction, the results of copper corrosion tests, and oxidations at 210 and 250 F. The oxidation results are given as pounds of drop over hours and give a good idea of the efficiency of the inhibitor. Readings were made at 24 hour intervals except in a few cases in which a rapid fall was noticed. In some cases the drop occurred over the week and where there was a 72 hour interval between readings. This occasionally ac-

TABLE I
Antioxidants for Greases

No.	Antioxidant	Conc. % by Wt.	Type of Grease	ASTM Unworked Pen.	Reaction	Copper Corrosion	Oxidation Results Pounds Drop/Hours	
							210 F	250 F
1	Base Grease		Lithium soap-mineral oil	286	Alkaline		48/24	
2	Dilauryl Selenide	0.1	Lithium soap-mineral oil	263	Alkaline	Passed	58/48	
		0.2	Lithium soap-mineral oil	243	Alkaline	Passed	92/408	
		0.3	Lithium soap-mineral oil	247	Alkaline	Passed	1/1064	60/48
3	Diocetyl-diphenylamine	0.1	Lithium soap-mineral oil	248	Alkaline		25/45	
		0.2	Lithium soap-mineral oil	258	Alkaline		64/144	
		0.3	Lithium soap-mineral oil	259	Alkaline		68/268	
4	N,N'-di-sec-butyl-p-phenylenediamine	0.1	Lithium soap-mineral oil	263	Alkaline	Passed	0/750	
		0.2	Lithium soap-mineral oil	263	Alkaline	Passed	2/750	

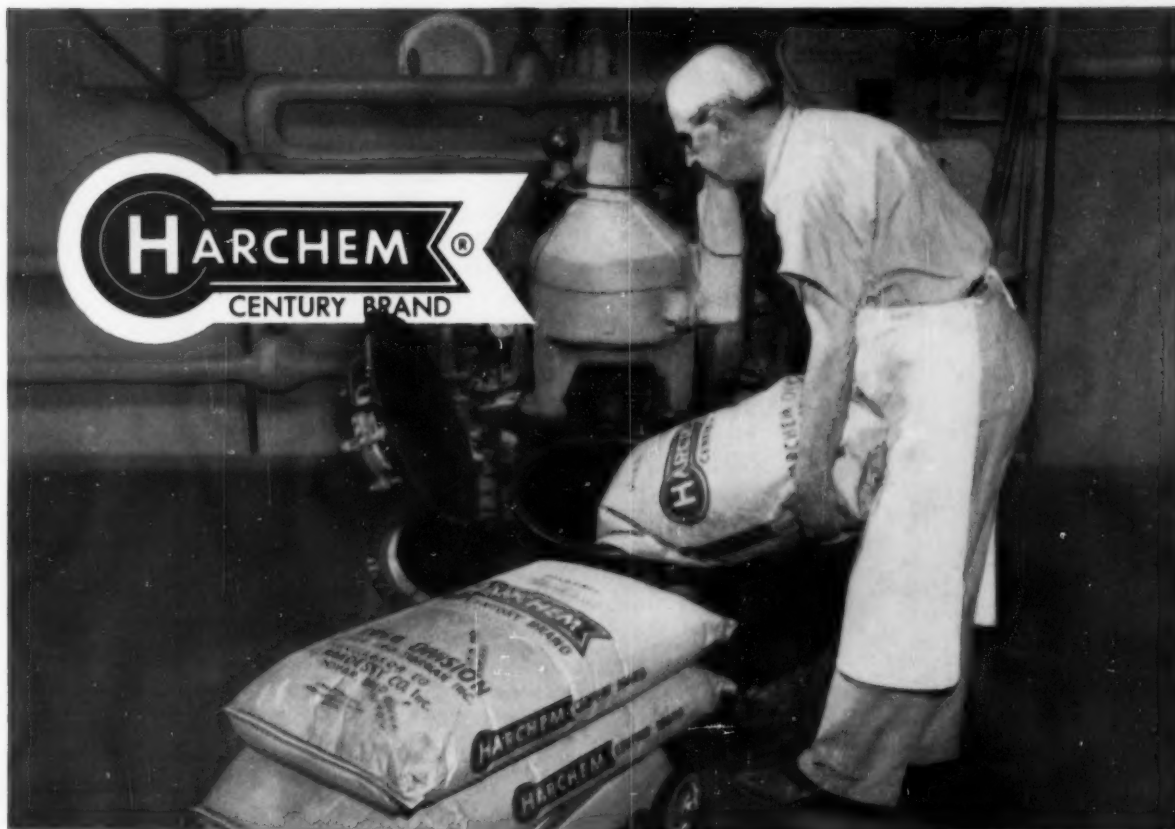
No.	Antioxidant	Conc. % by Wt.	Type of Grease	ASTM Unworked Pen.	Reaction	Copper Corrosion	Oxidation Results Pounds Drop/Hours	
							210 F	250 F
5	Di-tert-butyl-p-cresol	0.3	Lithium soap-mineral oil	258	Alkaline	Passed	2/750	
		0.2	Calcium soap-mineral oil	278	Acid	Passed	6/528	
		0.1	Lithium soap-mineral oil	248	Alkaline		9/72	
		0.2	Lithium soap-mineral oil	243	Alkaline		44/168	
		0.3	Lithium soap-mineral oil	255	Alkaline		54/216	
6	Octylatedarylalkylated diphenylamines	0.1	Lithium soap-mineral oil	259	Alkaline		40/192	
		0.2	Lithium soap-mineral oil	262	Alkaline		82/312	
		0.3	Lithium soap-mineral oil	263	Alkaline	Passed	6/504	
7	Phenothiazine	0.1	Lithium soap-mineral oil	253	Alkaline	Passed	0/504	
		0.2	Lithium soap-mineral oil	263	Alkaline	Passed	2/504	
		0.3	Lithium soap-mineral oil	256	Alkaline	Passed	2/504	32/1000
		1.0	Lithium soap-mineral oil		Alkaline			30/1400
8	Selenium di-ethyl-dithiocarbamate	0.1	Lithium soap-mineral oil	251	Alkaline		60/48	
		0.2	Lithium soap-mineral oil	247	Alkaline		80/120	
		0.3	Lithium soap-mineral oil	251	Alkaline		72/144	
9	A Mixture of Amines*	0.3	Calcium soap-mineral oil	275	Alkaline			70/522
		0.1	Lithium soap-mineral oil	243	Alkaline	Passed	2/504	
		0.2	Lithium soap-mineral oil	248	Alkaline	Passed	2/504	
		0.3	Lithium soap-mineral oil	242	Alkaline	Passed	2/504	60/48
		1.0	Lithium soap-mineral oil		Alkaline	Passed		22/1800
		0.3	Lithium soap-Diester	320	Alkaline	Passed	2/528	
		0.2	Calcium soap-mineral oil	304	Acid	Passed	4/504	85/135
		0.25	Lithium soap-mineral oil	227	Alkaline	Passed	90/240	
10	A Mixture of Amines + A Metal Dithiocarbamate*	0.50	Lithium soap-mineral oil	226	Alkaline	Passed	4/504	
		0.75	Lithium soap-mineral oil	225	Alkaline	Passed	4/504	30/380
		1.0	Lithium soap-mineral oil					30/700
		0.3	Lithium soap-Monoester	257	Alkaline	Passed	8/528	
		0.2	Calcium soap-mineral oil	313	Acid	Failed	10/504	
		0.2	Lithium-calcium soap-mineral oil	328	Alkaline	Passed	0/504	

*Commercial preparations sold for grease or rubber additives.

TABLE 1—Continued

No.	Antioxidant	Conc. % by Wt.	Type of Grease	ASTM Unworked Pen.	Reaction	Copper Corrosion	Oxidation Results Pounds Drop/Hours	
							210 F	250 F
		0.2	Lithium-calcium soap-Diester	308	Alkaline	Passed	0/504	
11	4-Tert-butyl-2-phenyl- phenol	0.1	Lithium soap- mineral oil	267	Alkaline		35/48	
		0.2	Lithium soap- mineral oil	276	Alkaline		28/48	
		0.3	Lithium soap- mineral oil	272	Alkaline		60/72	
		0.2	Lithium soap- Diester	263	Alkaline		90/192	
		0.2	Lithium soap- Monoester	302	Alkaline		60/192	
12	s-Diphenylcarbazone	0.3	Lithium soap- mineral oil	312	Alkaline	Failed	3/528	
		0.3	Lithium soap- Diester	263	Alkaline	Failed	0/504	
		0.3	Lithium soap- Monoester	292	Alkaline	Failed	1/504	
		0.2	Calcium soap- mineral oil	236	Acid		70/24	
13	Diphenylthiourea	0.3	Lithium soap- mineral oil	267	Alkaline		58/48	
14	Diphenylguanidine	0.3	Lithium soap- mineral oil	237	Alkaline		70/24	
15	Tetramethyldiamino- diphenylmethane	0.3	Lithium soap- mineral oil	256	Alkaline	Passed	0/528	30/18
		0.3	Lithium soap- Diester	290	Alkaline	Passed	3/504	
		0.3	Lithium soap- Monoester	256	Alkaline	Passed	11/528	
		0.3	Lithium-calcium soap-mineral oil	279	Alkaline	Passed	5/504	60/18
		0.2	Calcium soap- mineral oil	265	Acid	Passed	2/528	
16	p-Hydroxydiphenylamine	0.3	Lithium soap- mineral oil	275	Alkaline	Passed	5/528	
17	Zinc dibutyldithio- carbamate	0.3	Lithium soap- mineral oil	281	Alkaline	Failed	0/528	
18	2,6-Di-tert-butyl-4- methylphenol	0.3	Lithium soap- mineral oil				50/240	
		0.2	Calcium soap- mineral oil				30/48	
19	s-Di-b-naphthyl-p- phenylenediamine	0.1	Lithium soap- mineral oil	275	Alkaline	Passed	2/528	
		0.3	Lithium soap- mineral oil	270	Alkaline	Passed	2/528	60/500
		1.0	Lithium soap- mineral oil					30/1200
		0.3	Lithium soap- Diester	315	Alkaline	Passed	2/528	
		0.2	Calcium soap- mineral oil	250	Acid	Passed	6/672	
		0.3	Lithium-calcium		Alkaline	Passed	0/504	8/504
20	P,P'-diaminodiphenyl- methane	0.3	Lithium soap- mineral oil	255	Alkaline	Passed	0/528	24/162
		0.2	Lithium-calcium soap-mineral oil	315	Alkaline	Passed	0/648	

*Commercial preparations sold for grease or rubber additives.



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TABLE 1—Continued

No.	Antioxidant	Conc. % by Wt.	Type of Grease	ASTM Unworked Pen.	Reaction	Copper Corrosion	Oxidation Results	
							Pounds Drop/	Hours
							210 F	250 F
21	Zinc di-2-ethylhexyl dithiocarbamate	0.1	Lithium soap- mineral oil	233	Alkaline	Passed	2/504	40/48
		0.2	Lithium-calcium soap-mineral oil	292	Acid		50/196	
22	Cadmium di-2-ethyl- hexyldithiocarbamate	0.2	Lithium-calcium soap-mineral oil	363	Alkaline		58/240	
		0.1	Lithium soap- mineral oil	246	Alkaline	Passed	2/504	50/48
23	Sulfur-Phosphorous* Composition	0.3	Lithium soap- mineral oil	285	Alkaline	Failed	40/504	
24	Phosphite ester of* alkylated phenol	0.3	Lithium soap- mineral oil	278	Alkaline	Failed	10/504	
25	Substituted Phenol*	0.3	Lithium soap- mineral oil	274	Alkaline	Passed	84/192	
26	2-Benzoylamino-4- chlorotoluene	0.2	Lithium-calcium soap-mineral oil	308			20/96	
		0.2	Calcium soap- mineral oil	288	Acid		50/24	
27	Methyl Violet	0.3	Lithium soap- mineral oil	278			20/48	
28	Lead-di-2-ethylhexyl- dithiocarbamate	2.0	Lithium soap- mineral oil	245	Alkaline	Passed	0/552	80/114
29	P,P'-benzylidene bis (N,N'-dimethylaniline)	0.3	Lithium soap- mineral oil	235	Alkaline	Failed	2/936	60/24
		0.1	Lithium-calcium	278	Alkaline	Failed	4/600	76/18
30	p-Phenylenediamine	0.3	Lithium soap- mineral oil	257	Alkaline	Passed	0/552	80/162
		0.2	Lithium-calcium soap-mineral oil	317	Acid	Passed	18/744	25/42
31	N,N'-diphenylbenzi- dine	0.3	Lithium soap- mineral oil	250	Alkaline	Passed	12/552	
32	Amine Mixture*		Lithium soap- mineral oil	237	Alkaline	Passed	0/552	42/90
33	Phenyl-a-naphthylamine	0.3	Lithium soap- mineral oil	250	Alkaline	Passed	0/552	85/162
34	2-Mercaptobenzothiozole	0.3	Lithium soap- mineral oil	248	Alkaline		80/72	
35	Diphenyl-p-phenylene- diamine	0.3	Lithium soap- mineral oil	247	Alkaline	Passed	0/504	50/42
36	Dipentamethylene- thiuramtetrasulfide	0.3	Lithium soap- mineral oil	285	Alkaline		36/92	
37	N-phenyl-N'-cyclohexyl- p-phenylenediamine	0.3	Lithium soap- mineral oil	265	Alkaline	Passed	3/504	54/500
		0.3	Lithium-calcium soap-mineral oil	254	Alkaline	Passed	3/528	6/672
38	Di-p-methoxydiphenyl- amine	0.3	Lithium soap- mineral oil	262	Alkaline		100/92	
39	2, 2'-Dihydroxy-5, 5'- diamino-diphenylamine	0.3	Lithium soap- mineral oil	262	Alkaline		20/216	
		0.1	Lithium-calcium soap-mineral oil	270	Alkaline		86/96	
40	4, 6-Diamino-m-cresol methylether	0.3	Lithium soap- mineral oil	274	Acid	Passed	0/868	42/162
		0.1	Lithium-calcium soap-mineral oil	273	Alkaline	Passed	4/600	74/114
		0.1	Calcium soap- mineral oil	324	Acid	Passed	34/504	

*Commercial preparations sold for grease or rubber additives.

TABLE 1—Continued

No.	Antioxidant	Conc. % by Wt.	Type of Grease	ASTM Unworked Pen.	Reaction	Copper Corrosion	Oxidation Results	
							Pounds Drop/ 210 F	Hours 250 F
41	Guaiacol	0.1	Lithium soap-mineral oil	248	Alkaline		94/288	
		0.1	Lithium-calcium soap-mineral oil	293	Alkaline	Passed	2/600	62/18
42	Propyl Gallate	0.1	Lithium soap-mineral oil	308	Alkaline	Passed	2/624	48/42
		0.1	Lithium-calcium soap-mineral oil	287	Alkaline	Passed	2/600	12/18
		0.1	Calcium soap-mineral oil	290	Acid		40/48	
43	N,N'-di-4(2, 6-dimethyl-heptyl)-p-phenylenediamine	0.3	Lithium soap-mineral oil	255	Alkaline	Passed	2/504	50/24
44	N, N'-di-2-octyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	268	Alkaline	Passed	2/504	50/160
45	N,N'-di-3 (5-methyl-heptyl)-p-phenylene-diamine	0.3	Lithium soap-mineral oil	253	Alkaline	Passed	4/504	30/20
46	N,N'-di-2-undecyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	248	Alkaline	Passed	2/504	20/48
		0.3	Lithium-calcium soap-mineral oil	236	Alkaline	Passed	0/504	60/48
47	N,N'-di-2-nonyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	265	Alkaline	Passed	2/504	22/192
48	N, N'-di-2-ethyl hexyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	270	Alkaline	Passed	2/504	50/72
49	N, N'-di-4(2, 6, 8-trimethyl-nonyl)-p-phenylenediamine	0.3	Lithium soap-mineral oil	273	Alkaline	Passed	4/624	30/288
50	N, N'-bis (p-sec-butyl-amino-phenyl) 2, 3-butane diamine	0.3	Lithium soap-mineral oil	249	Alkaline	Passed	0/624	50/288
		0.3	Lithium-calcium soap-mineral oil	313	Alkaline	Passed	90/480	28/24
51	N, N'-di-sec-butyl-2-methoxy-p-phenylene-diamine	0.3	Lithium soap-mineral oil	258	Alkaline	Passed	2/600	20/80
52	N, N'-di-sec-butyl-1, 4-naphthylenediamine	0.3	Lithium soap-mineral oil	240	Alkaline	Passed	2/600	50/408
		0.3	Lithium-calcium soap-mineral oil	265	Alkaline	Passed	0/504	38/48
53	N, N'-di-sec-butyl-p-terphenylenediamine	0.3	Lithium soap-mineral oil	240	Alkaline		56/168	
54	N, N'-dicyclohexyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	264	Alkaline	Passed	0/528	22/120
55	Resorcinol disalicylate	0.3	Lithium soap-mineral oil	318	Alkaline	Passed	50/408	
56	Bisphenol-a-disalicylate	0.3	Lithium soap-mineral oil	310	Alkaline	Passed	30/360	
57	Mixture of Amines*	0.3	Lithium soap-mineral oil	276	Alkaline	Passed	0/900	70/96
58	Mixture of Sulfur Compounds*	0.3	Lithium soap-mineral oil	268	Alkaline		40/18	20/18
59	O, O, O-triisooctyl-phosphorothioate	0.3	Lithium soap-mineral oil	298	Alkaline		60/18	60/18
60	N, N'-di-(1-methylhexadecyl)-p-phenylenediamine	0.3	Lithium soap-mineral oil	275	Alkaline	Passed	0/936	60/90
61	N, N'-di-(1-methylocta-decyl)-p-phenylenediamine	0.3	Lithium soap-mineral oil	278	Alkaline	Passed	0/1620	40/40

*Commercial preparations sold for grease or rubber additives.

TABLE 1—Continued

No.	Antioxidant	Conc. % by Wt.	Type of Grease	ASTM Unworked Pen.	Reaction	Copper Corrosion	Oxidation Results	
							Pounds Drop/Hours 210 F	250 F
52	Phenyl-p-naphthylamine*	0.3	Lithium soap-mineral oil	270	Alkaline	Passed	0/1224	70/120
63	Diphenyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	267	Alkaline	Passed	0/1224	70/120
64	A Mixture of Amines*	0.3	Lithium soap-mineral oil	296	Alkaline	Passed	0/600	17/600
64	A Mixture of Amines*	0.15	Lithium-calcium soap-mineral oil	263	Alkaline	Passed	0/600	28/600
		0.3	Calcium soap-mineral oil	300	Alkaline	Passed	0/600	10/600
65	Ion Exchange Resin Sulfonic Acid Type	0.3	Lithium soap-mineral oil	268	Alkaline		30/20	
66	Ethylene Diamine Tetra acetic acid-sodium salt	0.3	Lithium soap-mineral oil	227	Alkaline		50/140	
67	N, N'-di-(1-methyldodecyl) p-phenylenediamine	0.3	Lithium soap-mineral oil	238	Alkaline	Passed	0/648	30/48
68	Ion Exchange Resin Modified amine type	0.3	Lithium soap-mineral oil	250	Alkaline		50/18	50/18
69	N, N'-di-2-tridecyl-p-phenylenediamine	0.3	Lithium soap-mineral oil	236	Alkaline	Passed	4/504	70/360
		0.3	Lithium-calcium soap-mineral oil	260	Alkaline	Passed	0/504	38/360
70	Trialkyl Phenol*	0.3	Lithium soap-mineral oil	252	Alkaline	Passed	80/336	70/360
		0.3	Lithium-calcium soap-mineral oil	274	Alkaline	Passed	0/528	38/360

*Commercial preparations sold for grease or rubber additives.

counts for the large pressure drop recorded.

In order to show more clearly the progress of oxidation in terms of pressure drop, and to emphasize certain differences in their behavior, graphs of selected inhibitors are shown in Figures 2 through 13.

In Figure 2 are shown the results obtained from tetramethyldiaminodiphenylmethane. It shows an almost linear drop of pressure with time for all types of grease. The 250 F results are poor for both the lithium soap and lithium calcium soap greases.

Continued on page 20

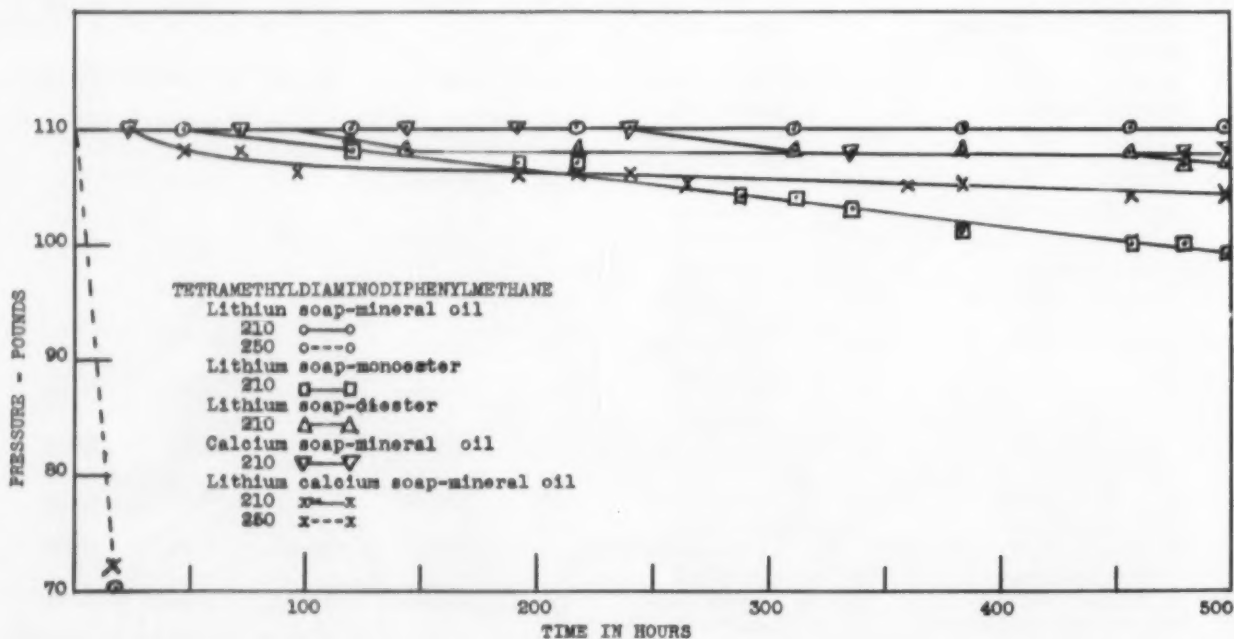


FIGURE 2



Lubrication of weather-exposed conveyor belt bearings is one of the many uses for which Bentone 34 grease is especially recommended.

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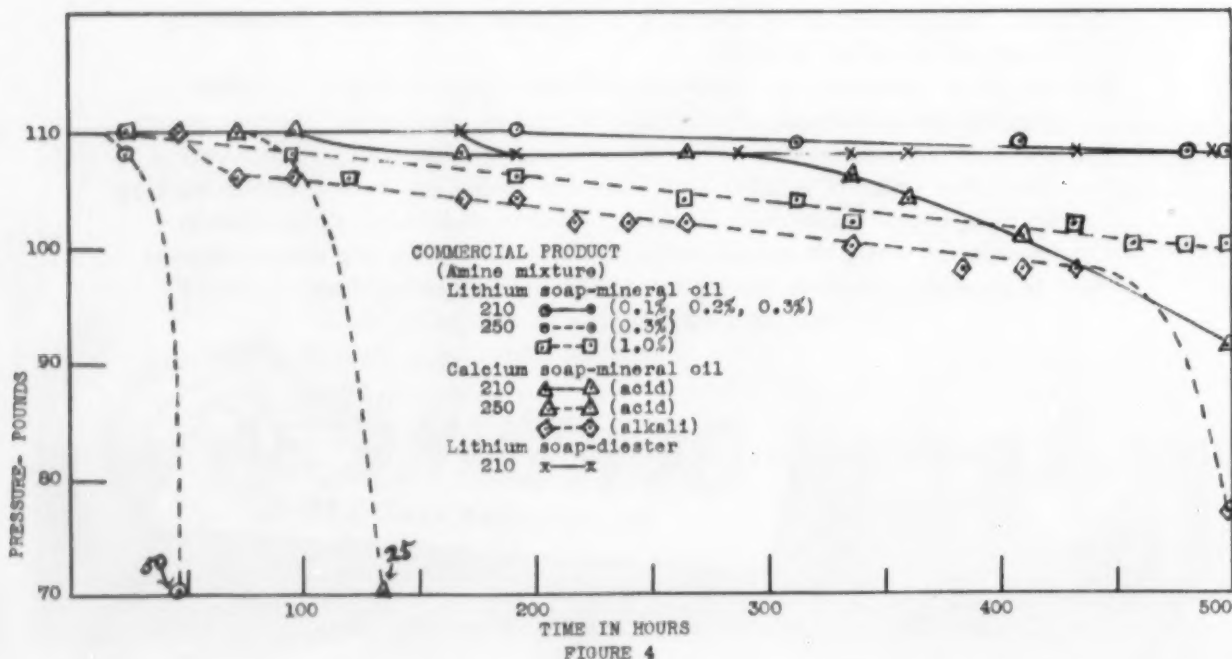
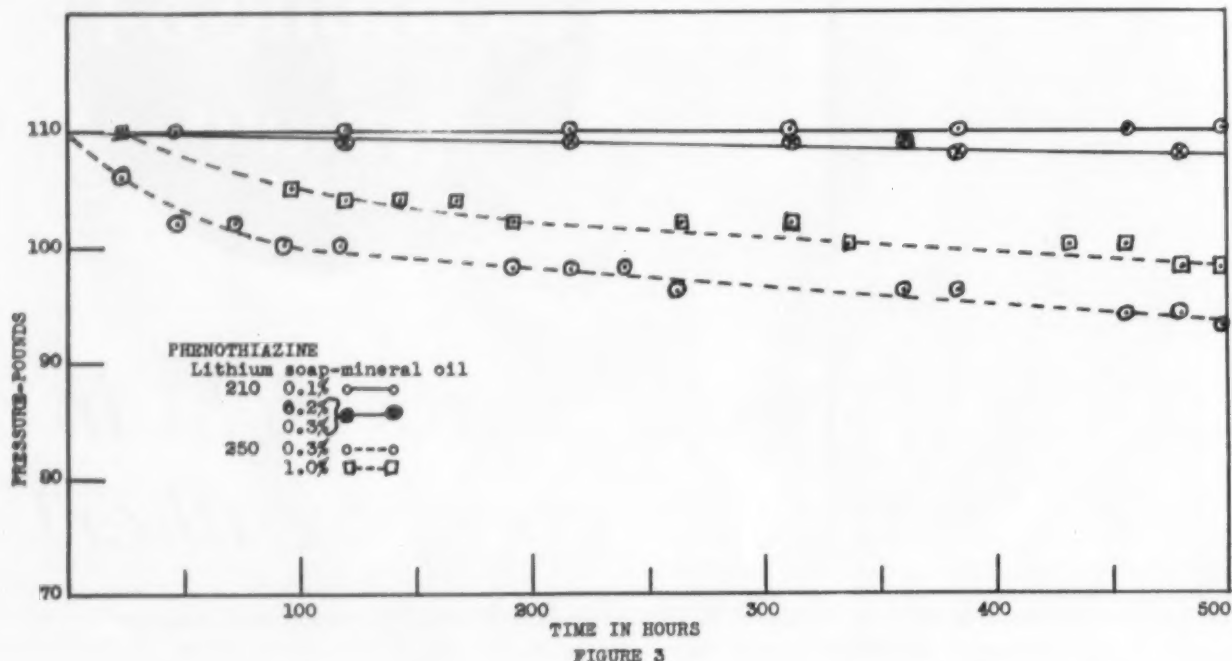
BAROID DIVISION

P. O. BOX 1475, HOUSTON 1, TEXAS

The results for phenothiazine are shown in Figure 3. This compound gave slightly better results at 0.1% concentration than for the 0.2% or 0.3% concentrations at 210 F. However, at 250 F the 1% concentrations showed slightly better results than the 0.3%. Both concentrations show a rapid drop at first and then a leveling off for the 250 F curve.

The results in Figure 4 are those of a commercial product which is described as a mixture of amines. The results of 210 F oxidation are all good showing very

little drop in 500 hours except for the calcium soap mineral oil grease which was slightly acid. The concentration apparently had little effect since the drop was the same for the 0.1, 0.2 and 0.3% concentrations at 210 F. At 250 F the results are quite different. The 0.3% in lithium soap and the acid calcium soap greases showing induction periods of approximately 25 and 100 hours respectively. The 1% in lithium soap and the alkaline lime soap show up very well at this temperature with induction periods of 500 + hours and 450 hours.



Another commercial product, said to be a mixture of amines and a metal alkyl dithiocarbamate is shown in Figure 5. This one shows the effect of concentration and possibly the difference in soap used. For the 210 F oxidations the 0.25% in lithium soap grease had an induction period of slightly over 200 hours. Both the 0.5% and 0.75% in lithium soap gave only 4 pounds drop in 500 hours. On the other hand the lithium calcium soap-mineral oil and lithium calcium soap diester greases gave

no drop in 500 hours with only 0.2 concentration of antioxidant. The calcium soap mineral oil grease with 0.2% and the lithium soap-monoester with 0.3% of antioxidant also showed up well at this temperature. Only two greases were tested at 250 F in this case. They were the lithium soap greases with 0.75% and 1.0% of antioxidant. As can be seen from the graph the 0.75% concentrations had a drop of 30 pounds in 350 hours and the 1% approximately 20 pounds in 500 hours. In both

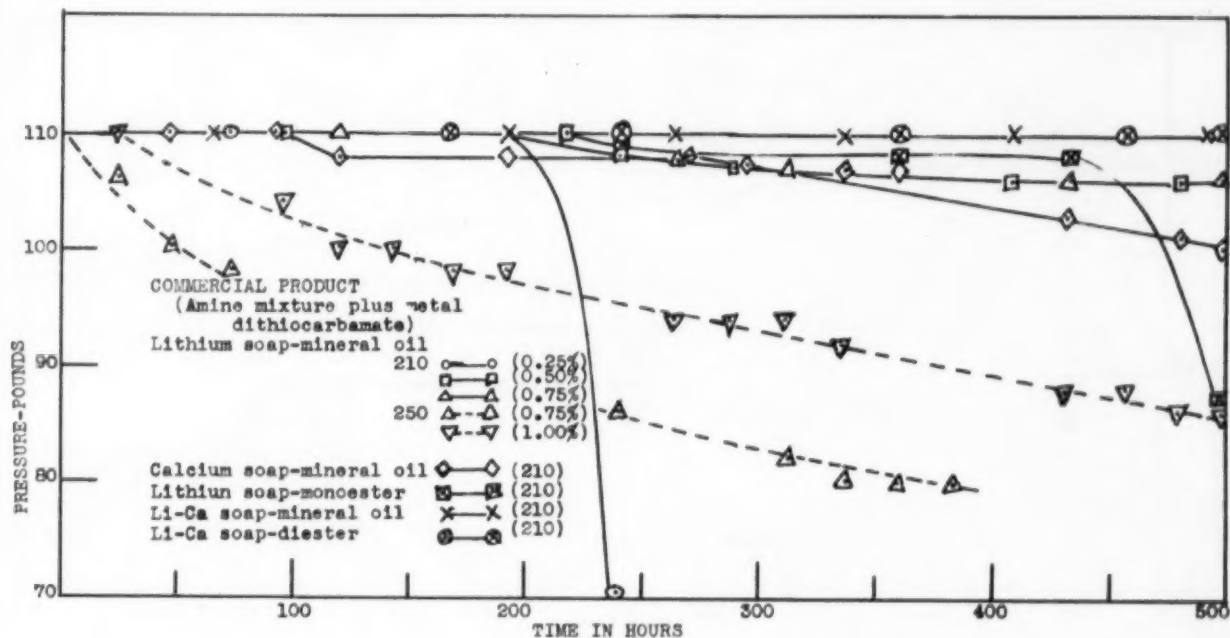


FIGURE 5

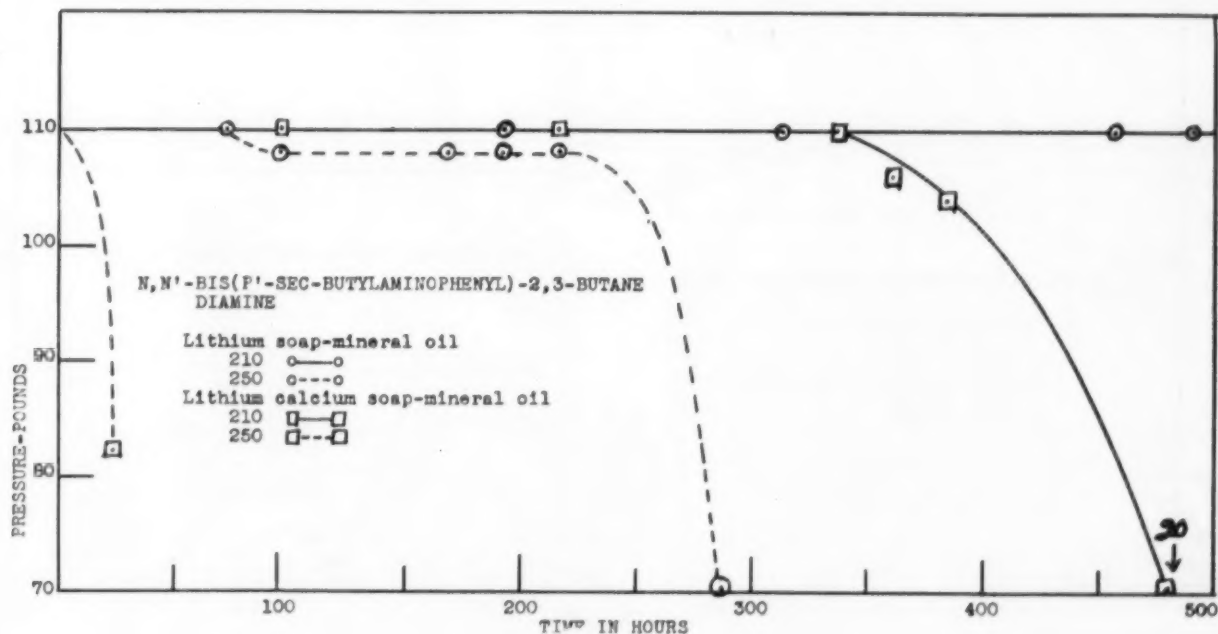


FIGURE 6

cases the drop is more rapid at first and gradually slows down to an almost linear relationship after 150 to 200 hours.

In Figure 6 are shown the results obtained from N,N'-bis-(p-sec-butylaminophenyl)-2,3, but butanediamine. It provided protection in 0.3% concentration in lithium soap grease for over 500 hours and in a lithium calcium soap grease for approximately 400 hours. At 250 F in the same concentrations it gave protection to a lithium soap grease

for 250 hours and for the mixed soap grease about 24 hours.

The next four figures show some of the many phenylenediamines tested. Figure 7 for p-phenylenediamine shows good results for both the lithium and mixed soap greases at 210 F but rather poor results at 250 F. Figure 8 indicates similarly good results at 210 F for N,N'-di-2-tridecyl-p-phenylenediamine in both types of greases and appreciably better results at 250 F.

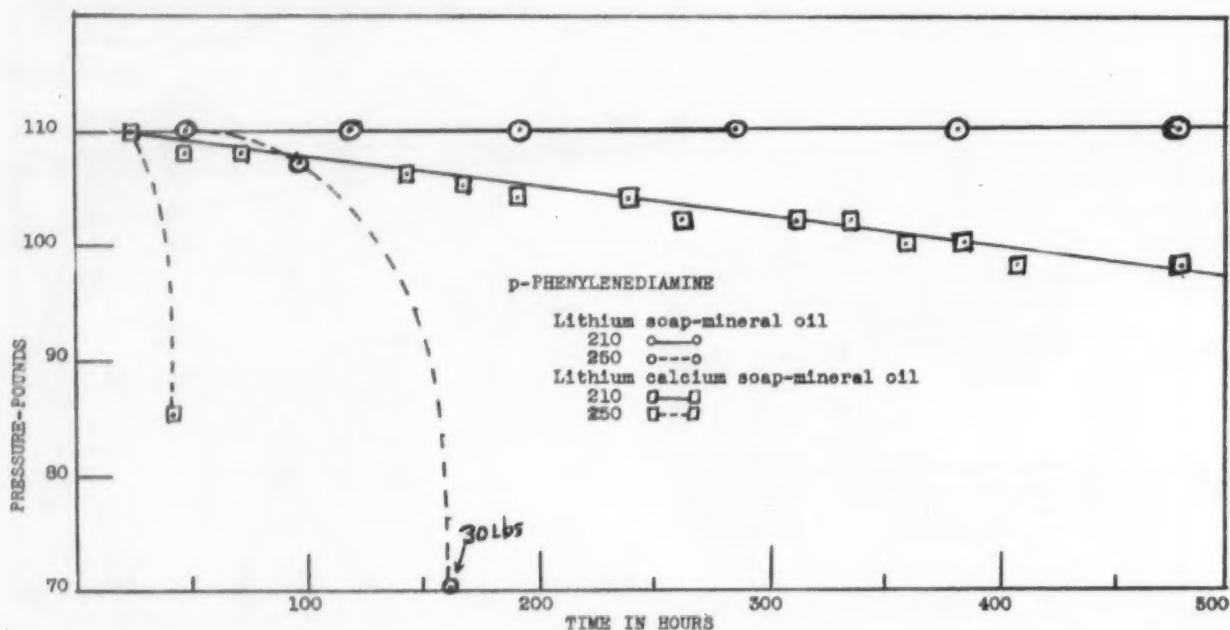


FIGURE 7

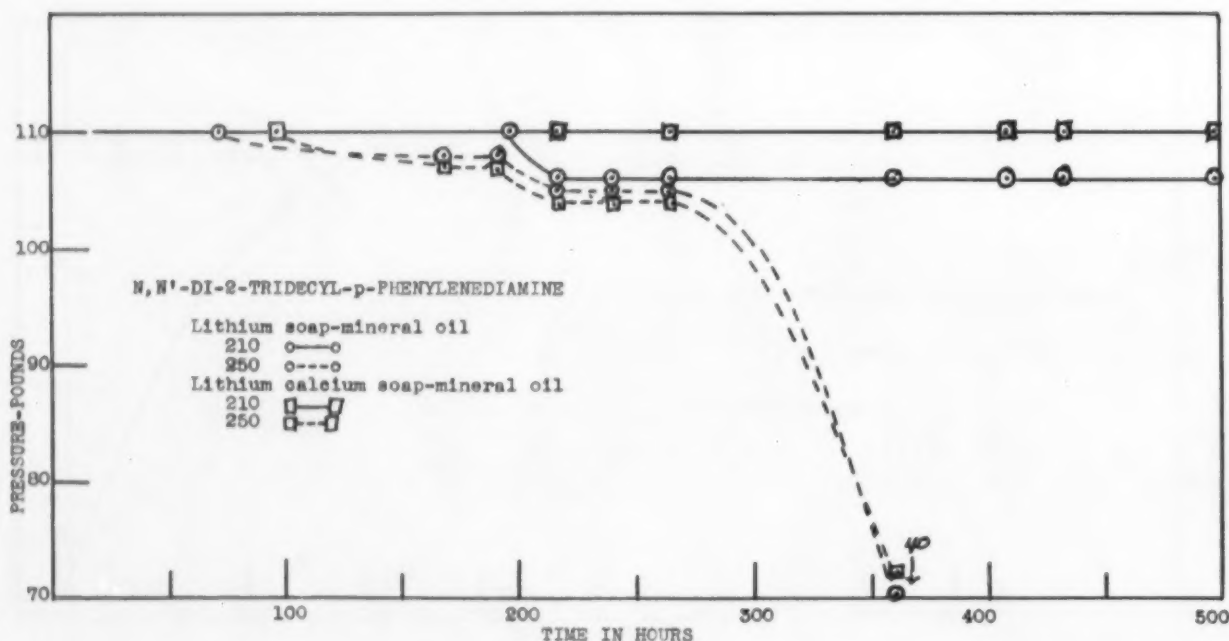


FIGURE 8

Figure 9 is of a ring substituted compound N-phenyl-N'-cyclohexyl-p-phenylenediamine. It shows equally good results at 210 F and much better at 250 F than the alkyl substituted compounds. Induction periods of over 400 and 500 hours being obtained for the higher temperatures.

For s-di-b-naphthyl-p-phenylenediamine, shown in Figure 10 the results at 210 F are very good for all greases and concentrations used. The maximum drop be-

ing only 4 pounds in the 500 hours. Three greases were tested at 250 F with this inhibitor. The 0.3% concentration in lithium soap gave protection for almost 450 hours. The 1.0% lithium soap and 0.2% in lithium calcium soap grease gave protection for more than 500 hours.

A multisubstituted ring compound 4,6-diamino meta cresol methyl ether is shown in Figure 11. It displays good inhibition at 210 F for the three types of greases used. The calcium soap grease showing an induction

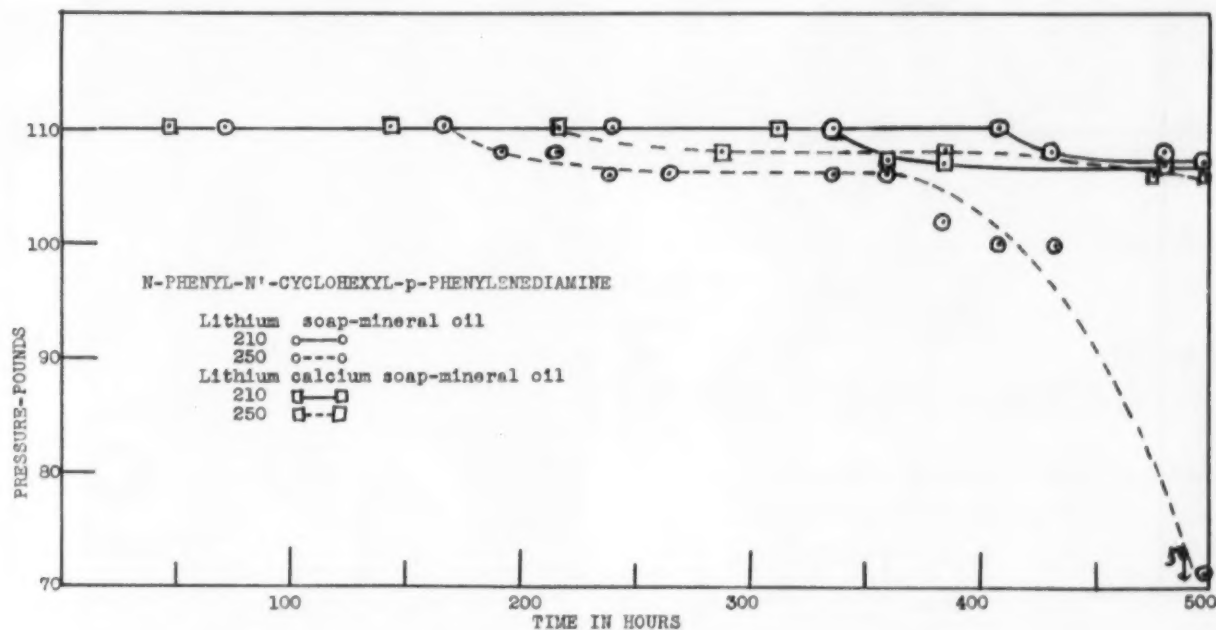


FIGURE 9

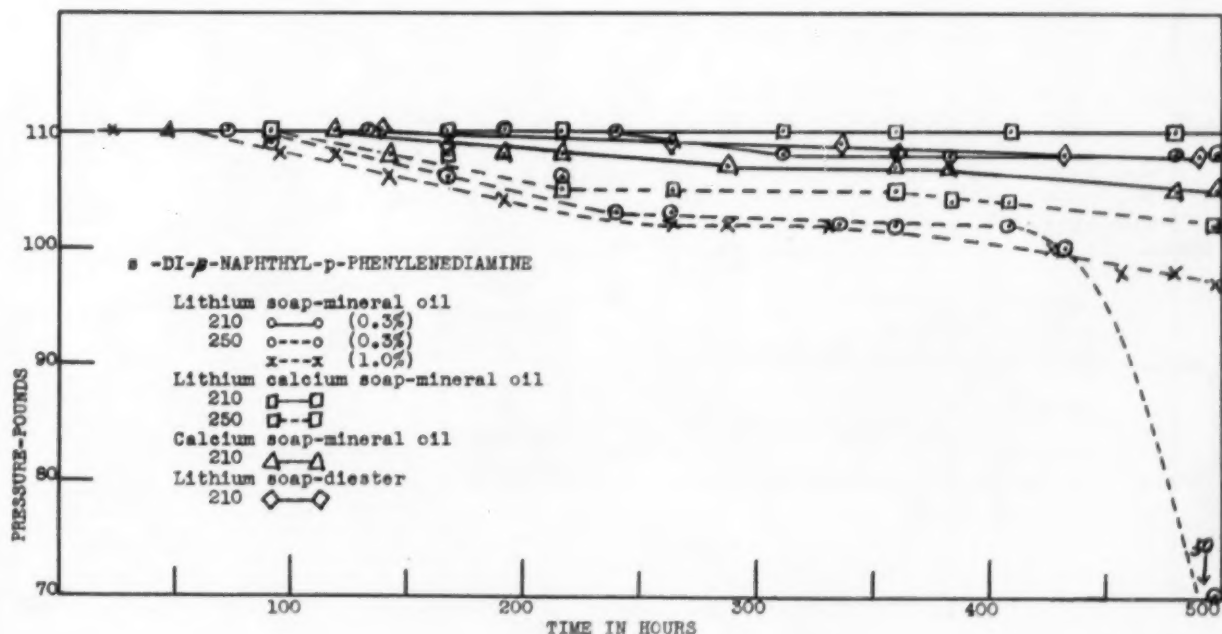


FIGURE 10

period just short of the 500 hours. The two greases tested at 250 F did not show induction periods greater than 150 hours.

Figure 12 is of another commercial antioxidant which is said to be a mixture of amines. None of the three greases showed any drop whatever at 210 F. At 250 F all greases showed an early pressure drop at around 100 hours. The pressure decrease became linear for all three after this initial drop.

The results obtained from another commercial product, said to be a trialkyl phenol, are shown in Figure 13. It inhibited the lithium soap grease for 300 hours at 210 F but showed no drop in 500 hours in a mixed soap grease. It protected for approximately 100 hours for both greases at 250 F.

Attempts to tie inhibiting ability to some structural detail did not prove very fruitful. As an example consider the phenylenediamines. As a group they displayed

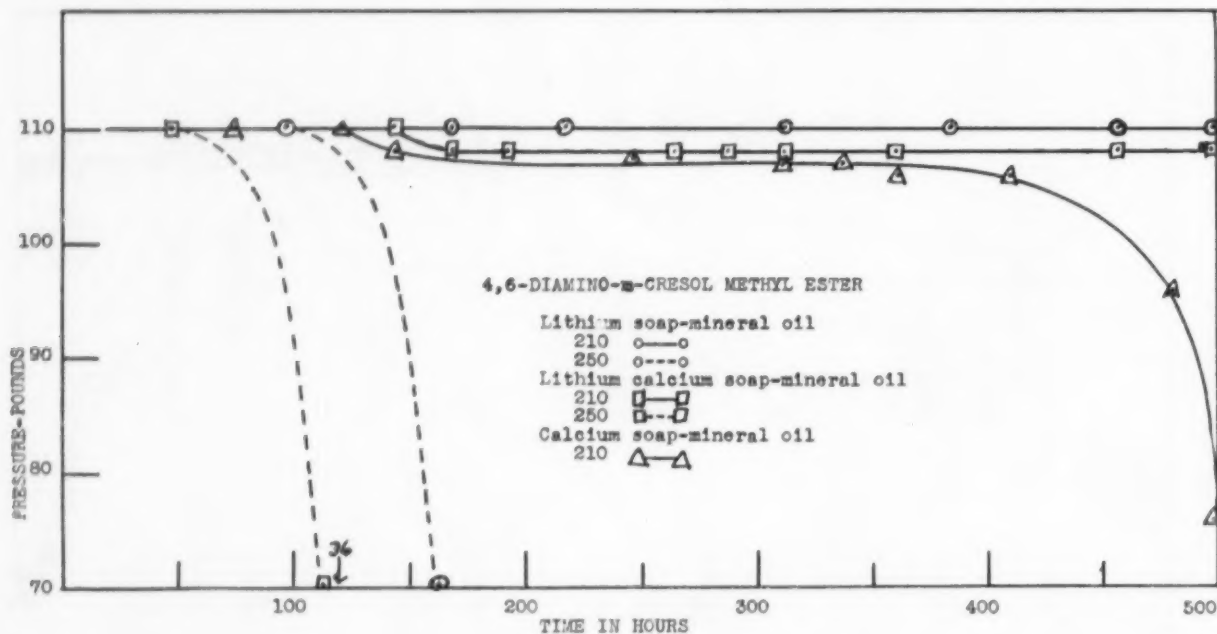


FIGURE 11

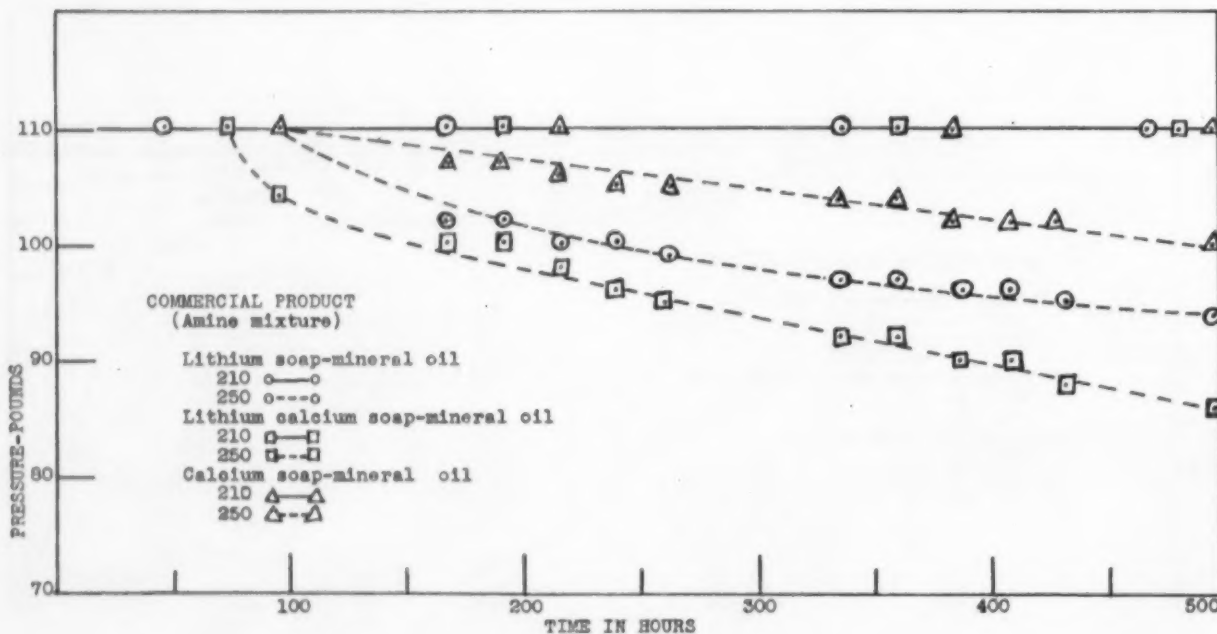


FIGURE 12



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exceptionally good inhibition at 210 F. Most of them were so equally effective at this temperature that it is impossible to differentiate among them. At 250 F there is a slight tendency for those of higher molecular weight to provide better inhibition. Table II lists seven of the alkyl substituted phenylenediamines in order of increasing chain length and atomic weight. The results of pressure drop/hours are given for the 0.3% concentration in lithium soap greases. The first five show a slight tendency to improve with increase in molecular weight or chain length but the last two, and others which can be observed in Table I, do not continue the trend. In Table III, which shows some aryl and ring substituted phenylenediamines, the lack of any relationship between inhibiting ability and molecular weight is at once apparent.

It was suggested that there might be a possible relation between the vapor pressures of a compound and its inhibiting ability, especially at higher temperatures. The vapor pressure of a number of the compounds used was available from another section of this laboratory.²⁸ These compounds are listed in Table IV in order of decreasing vapor pressures. The vapor pressures and pressure drop/hours for both 210 F and 250 F are given. There is clearly no connection between vapor pressures and inhibiting ability.

It is possible however, to make some general observations from the results of this study. First, the amines as a group and especially the phenylenediamines proved to be exceedingly good inhibitors. Very few of the many tried failed to give protection for from four to five hundred hours at 210 F. They also constituted the majority of those compounds or mixtures which proved most successful at 250 F as shown in Table I.

The substituted phenols did not show any outstanding antioxidant ability as a group. Three of them did inhibit

TABLE II
Molecular Weight and Inhibiting Ability of Alkyl Substituted Phenylenediamines 0.3% in Lithium Soap Mineral Oil Greases

Compounds	M.W.	Pounds Drop/Hours
		250 F
P-Phenylenediamine	108	80/162
N,N'-di-2-octyl-p-phenylenediamine ..	332	50/160
N,N'-di-2-Nonyl-p-phenylenediamine.	360	22/192
N,N'-di-4(2, 6, 8-trimethylnonyl)-p-phenylenediamine	442	30/288
N,N'-di-2-tridecyl-p-phenylene-diamine	474	70/360
N,N'-di-(1-methylhexadecyl)-p-phenylenediamine	584	60/90
N,N'-di-(1-methyloctadecyl)-p-phenylenediamine	640	40/40

TABLE III
Molecular Weight and Inhibiting Ability of Aryl and Ring Substituted Phenylenediamines 0.3% in Lithium Soap Mineral Oil Greases

Compounds	M.W.	Pounds Drop/Hours
		250 F
p-Phenylenediamine	108	80/162
Diphenyl-p-phenylenediamine	260	50/42
N-phenyl-N'-cyclohexyl-p-phenylenediamine	266	54/500
N,N'-dicyclohexyl-p-phenylene-diamine	272	22/120
s-Di-b-Naphthyl-p-phenylenediamine .	360	60/500

Continued on page 28

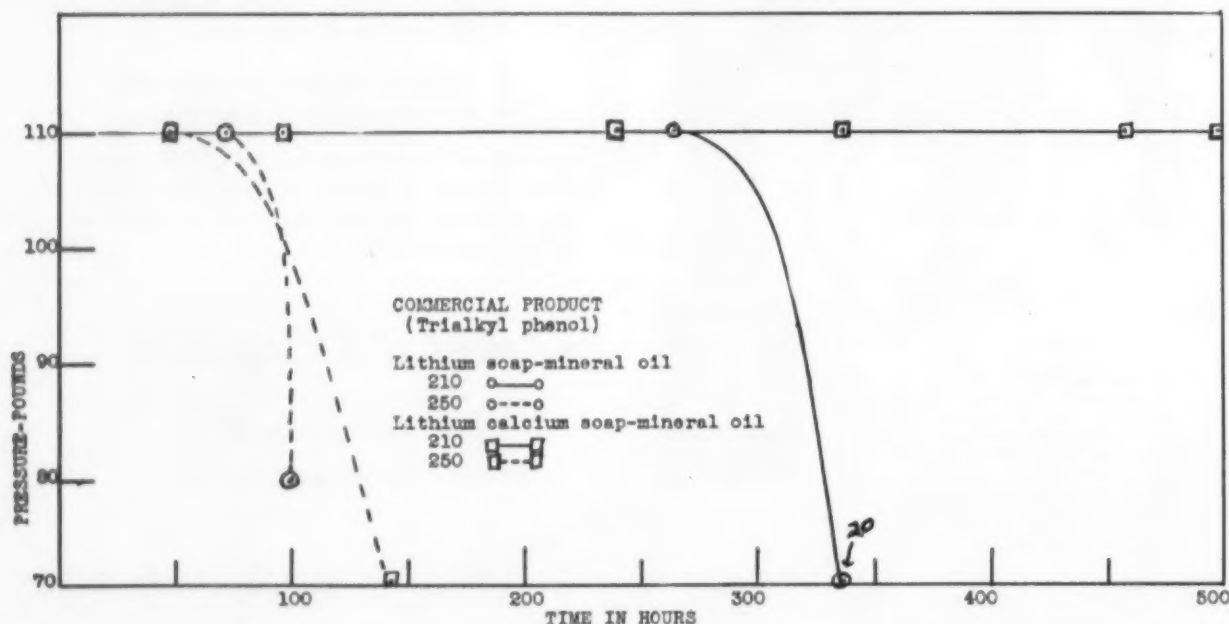


FIGURE 13



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TABLE IV
Comparison of Oxidation Results with Vapor Pressures of Antioxidants
0.3% in Lithium Soap Mineral Oil Greases

Chemical Name	Calculated Vapor Press. Mm Hg@212°F	Oxidation Results Pounds Drop/Hours	
		210°F	250°F
N,N'-di-(1'methyloctadecyl)-p-phenylenediamine	1.3×10^{-6}	0/504	40/40
N,N'-di-(1'methylhexadecyl)-p-phenylenediamine	2.4×10^{-6}	0/504	60/90
N,N'-di-(1'methyldodecyl)-p-phenylenediamine	3.7×10^{-6}	0/504	30/48
N,N'-di-sec-butyl-p-terphenylenediamine	2.0×10^{-4}	56/168	
N,N'-di-(2'undecyl)-p-phenylenediamine	4.1×10^{-4}	2/504	20/48
N,N'-di-octyl-p-phenylenediamine	5.4×10^{-3}	2/504	50/160
N,N'-di-nonyl-p-phenylenediamine	1.5×10^{-2}	2/504	22/192
N,N'-bis(p-sec-butylaminophenyl)2-3-butanediamine	3.6×10^{-2}	0/504	50/288
N,N'-di-sec-butyl(2-methoxy)p-phenylenediamine	1.4×10^{-1}	2/504	20/80
N,N'-di-sec-butyl-p-phenylenediamine	3.9×10^{-1}	0/504	

for over 500 hours at 210 F in some types of greases. They should be given consideration as inhibitors if price and supply are favorable.

The sulfur compounds, especially the metal dithiocarbamates, gave a good account of themselves. They also improved the antiwear characteristics of the greases containing them. The phosphorous and selenium compounds were too few to provide a basis for any general statement. They should improve the antiwear properties

of a grease and thus serve as possible dual additives.

None of the several miscellaneous compounds tried showed any pronounced inhibiting value except the dilauryl selenide in 0.3 concentration and the phosphite ester. They are as follows referring to the numbers of Table I; selenium compounds No. 2 and 8, a phosphorous compound No. 24, sulfur phosphorous compounds No. 23 and 59, two ion exchange resins No. 65 and 68 and a sequestering agent No. 66.

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COMPARISON OF LABORATORY AND FIELD BLEEDING TESTS FOR LUBRICATING GREASES



Typical Test Pail in Field Storage Experiment
Figure 1

By J. L. DREHER and A. L. McCLELLAN
California Research Corporation

NUMEROUS laboratory tests have been developed to determine the bleeding tendencies of lubrication greases.¹ The wide variety of tests used by the grease industry indicates that no test is recognized as capable of predicting the bleeding rate of greases in storage. Nearly every specification with a requirement pertaining to bleeding prescribes a different test.

The absence of a test known to be reliable is largely due to the lack of an established correlation between the results of laboratory and field tests. The lack of correlation is the result of the absence of quantitative field storage data. Published field storage data usually consist of qualitative observations of a number of greases whose surface conditions and storage history were not similar.

The experiments described in this paper were conducted to establish a correlation between the results from a new field storage test and a selected number of laboratory tests. The field data were obtained on 19 greases, 15 of which were commercial products and 4 experimental. In the laboratory, four methods were used to rate the greases: (1) and (2) procedures required by Specifications MIL-G-3278 and MIL-G-10924 (ORD) Amendment 2, (3) Crater Test,¹ and (4) Centrifugal Filtration Test, developed several years ago by Dr. G. M. Kibler of this laboratory.

The four tests represent two different ways of accelerating oil separation for the laboratory evaluation of bleeding tendencies. The first three tests use elevated temperatures. The fourth (run at room temperature) uses pressure resulting from centrifugal force.

Test Procedures

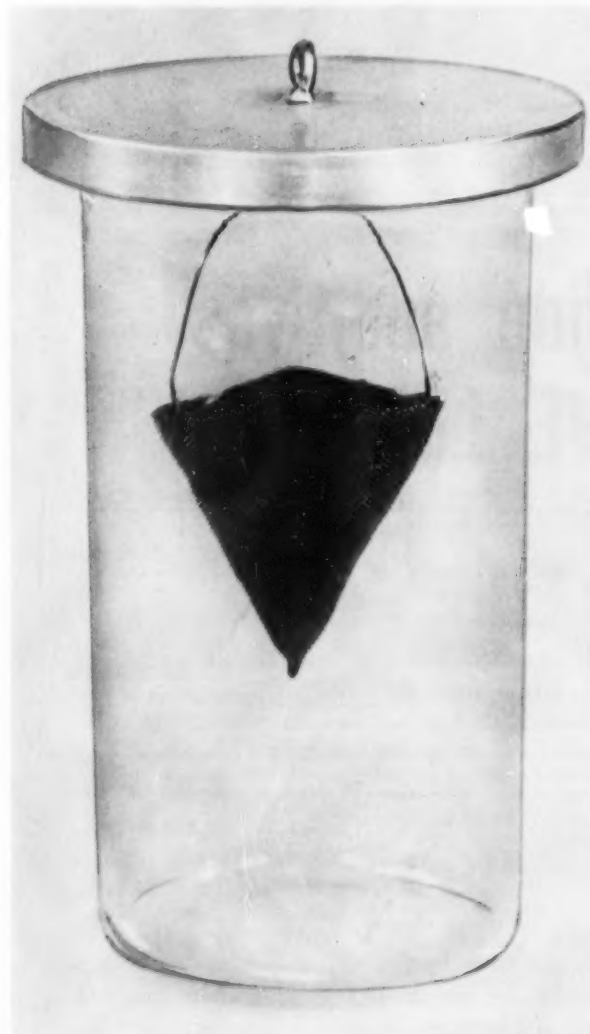
The field storage test was conducted using 35-pound pails of grease. At the start of the test, the top two inches of grease in each pail were carefully scraped off to remove

the effects of previous oil separation. Three uniform, conical depressions were then made in the surface by the insertion of 8-mesh screen cones. The cones were 4 inches in height and 3 inches in diameter. The grease forced through the screen during the insertion of the cone was removed. Two of the cones were left in the grease, but the third cone was carefully removed, leaving an unsupported conical depression in the grease. Figure 1 shows a typical test pail after preparation.

The test pails were covered, but not sealed, and stored without further protection under atmospheric conditions at Richmond, California. At periodic intervals the diameter of the separated oil pool in the depressions was measured and the volume calculated. During the month in which the results reported in Table I were obtained, the temperature varied from 49°F to 87°F, and the average minimum and maximum daily temperatures were 55°F and 72°F.

A duplicate set of pails was stored at Sacramento, California, where the temperature varied from 45°F to 105°F,

Figure 2—MIL-G-3278 Test



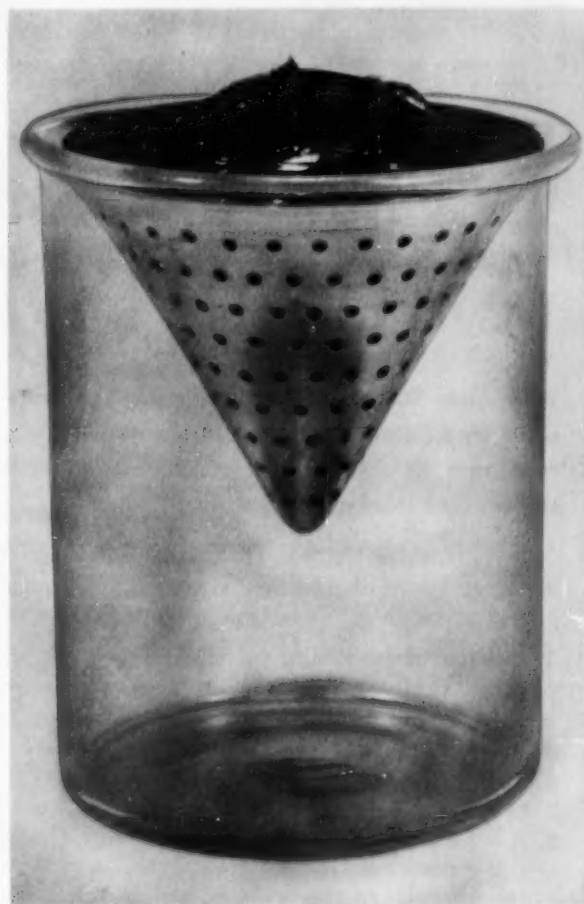
and the average minimum and maximum daily temperatures were 54°F and 85°F. As expected, the bleeding rate was higher at Sacramento than at Richmond because of the higher temperatures; however, the 19 greases were generally rated in the same order at both locations. The results of the tests at Sacramento are not included in the correlations below because the tests on all 19 of the greases were not started at the same time at that location. At both locations the order was established within one week from the start of the test and remained the same throughout the test period.

The laboratory bleeding tests required in Specification MIL-G-3278 and MIL-G-10924 (ORD) Amendment 2 are described in detail in those specifications. Briefly, in the MIL-G-3278 test 10 grams of grease in a nickel wire gauze cone is held for 30 hours at 210°F; the MIL-G-10924 test employs 10 grams of grease in a perforated nickel cone and lasts 50 hours at 160°F. The assembled apparatus used in these two tests are shown in Figures 2 and 3.

In the Crater Test,¹ approximately 45 grams of grease is placed in a 3-ounce can. The surface of the grease is shaped into a cone with the apex at a 1/8-inch hole in the bottom of the can. The hole permits the separated oil to

Continued on page 34

Figure 3—MIL-G-10924 Test
(Amendment 2)





Effective lubrication of torsion suspension bushings of heavy duty trailers has been a maintenance problem with many truckers. The bushing at the left was removed still in good condition after 160,000 miles of service.

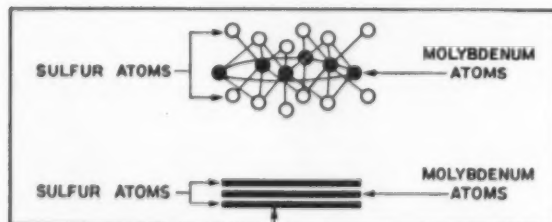
This bushing was lubricated with a chassis grease containing Moly-Sulfide additive. The bushing at the right, lubricated with ordinary chassis grease, needed replacement after 35,000 miles of service.

How Moly-Sulfide additives EXTEND EFFECTIVE LUBRICATION

Why Moly-Sulfide additives are used in lubricants by trucking fleet operators, railroads, aircraft and automotive manufacturers, oil well drillers and steel mills.

Moly-Sulfide has six characteristics which make it an ideal lubricant additive wherever mechanical action wipes or shears off the hydrodynamic film.

1. Because of its affinity for metals, Moly-Sulfide readily forms a film on metal surfaces.
2. Moly-Sulfide has a low coefficient of friction.
3. It has a high factor of durability.
4. Moly-Sulfide has a thermal stability of -100°F . to $+750^{\circ}\text{F}$.
5. It has a high chemical resistance to acids, alkalis and water.
6. It withstands high pressures, having a low shear strength and a high film strength.



Above, structural diagram of the Moly-Sulfide molecule. Below is a functional illustration of the laminar structure. Each lamina is composed of a layer of molybdenum atoms with a layer of sulfur atoms on each side.

What is Moly-Sulfide and how does it function in lubrication?

Mined in Colorado as molybdenite, purified Moly-Sulfide is a lead-grey material. It has a laminar molecular structure, with the Moly atoms sandwiched between layers of sulfur. (See illustration.) The sulfur atoms have an affinity for metal and

bond readily to metal surfaces, giving the film a *low shear strength*. This affinity is caused by a strong intermolecular bond between sulfur and metal. The lubrication results from the easy slippage of sulfur-to-sulfur atoms. As an additive to lubricants, the *Moly-Sulfide will readily form a film and when a grease or oil film is wiped away or sheared off, the Moly-Sulfide film sustains lubrication until a petroleum film reforms.*



Truck and passenger car builders and operators are making wide use of Moly-Sulfide greases for difficult lubrication jobs.

Lubricants containing Moly-Sulfide additive have over 30 established uses in the automotive, aircraft, railroad, oil drilling and steel industries.

Since Abraham Lincoln's time, railroads have been faced with a serious, recurring, *expensive* problem: hotboxes. Right now more than 14 million journal bearings are carrying heavy loads at high speeds on American railroads. These railroads have to deal with an average of 183,000 hotboxes a year at a cost of some \$90,000,000.

Initial field tests by at least three leading railroads have shown hotboxes can be reduced materially by the use of grease containing Moly-Sulfide. A way has been devised to apply greases containing Moly-Sulfide on the journals of railroad equipment. This application is supplemental to the oil waste system and as a result the Moly-Sulfide films that are formed sustain lubrication until the oil film is reestablished.

American automobile and truck manufacturers and their customers are now using lubricants containing Moly-Sulfide additive in at least 14 different applications. These include chassis points, ball joint suspensions, torsion suspension assemblies, fifth wheels, shackle bolts, king pins, valve stems, automatic window mechanisms, wind-shield wiper mechanisms, seat adjusters, drive shaft splines.

In aircraft, Moly-Sulfide is added to aircraft greases. In jet engines under exacting conditions of temperature and pressure it is used on turbine shafts, splines and gear reduction units.

In other industries, Moly-Sulfide is being used in lubrication jobs which formerly presented serious difficulties. A Florida cement plant is using gear compound containing Moly-Sulfide to lubricate



Aircraft manufacturers are using Moly-Sulfide greases on many types of ball and joint suspension lubrication.

rack gears and a Michigan manufacturer uses Moly-Sulfide as an additive to drawing compounds for drawing stainless steel hub caps. In New York a baker of crackers and cookies is using Moly-Sulfide grease for lubrication of oven chains which must operate at high temperatures. In Louisiana an oil well drilling contractor is using Moly-Sulfide additive in tool joint compounds. He reports that disjoints when drilling below 15,000 feet is no problem now: no galling, welding or stripped threads.



Oil well drilling contractors are using Moly-Sulfide additives to tool joint compounds.

Lubrication engineers are offered information and help in evaluating the use of Moly-Sulfide as an additive to lubricants by the Climax Molybdenum Co.

Currently Moly-Sulfide is being investigated by many petroleum research laboratories and lubricant users. They are interested in studying, under practical working conditions, the ability of Moly-Sulfide to increase effective lubrication.

If insuring effective lubrication is a problem facing your company, Moly-Sulfide additives may be a solution. Climax Molybdenum Company is the principal source of this product. If you need authoritative information, please get in touch with us and we will be pleased to send you literature on Moly-Sulfide and the sources of supply for experimental lubricants containing Moly-Sulfide.

Department 59

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drain into a catch pan placed below. The sample is maintained for 200 hours at 130°F in the apparatus, shown in Figure 4.

The principal components of the apparatus used in the Centrifugal Filtration Test are a Coors 0000 Büchner funnel with a shortened spout, and a small laboratory centrifuge. The funnel with a Whatman No. 2 filter paper is weighed on an analytical balance. One gram of grease is loaded into the funnel, which is then reweighed. The loaded funnel is mounted in a short, flat-bottomed glass tube with a piece of rubber tubing folded over the lip of the tube to form a seat for the funnel. The assembly is supported on a rubber pad in a 50-ml metal shield in a clinical centrifuge. The centrifuge is rotated at 2700-2800 rpm for 30 minutes at room temperature (75°F). The radius of the circle described by the filtering surface is 10 cm, so that the centrifugal force is approximately 840G. The Büchner funnel is reweighed after centrifug-

ing to determine the oil loss. The assembled apparatus is shown in Figure 5.

Results

The results of the field storage test after one month at Richmond, California, and of the four laboratory tests are given in Table I. The relations between the results of the four laboratory tests and those of the field storage test are shown graphically in Figures 6, 7, 8, and 9. The physical properties of the test greases are given in Table II.

With the exception of the Crater Test,¹ which was run only once, each laboratory test was run in duplicate, and the average result is reported. The value reported for the field storage test is the average volume of the separated oil in the two depressions supported by screen cones. The oil in the unsupported depressions approximated that in the supported depressions. With the softer greases, the removal of the cones disturbed the surface so that the separated oil could not be measured accurately.

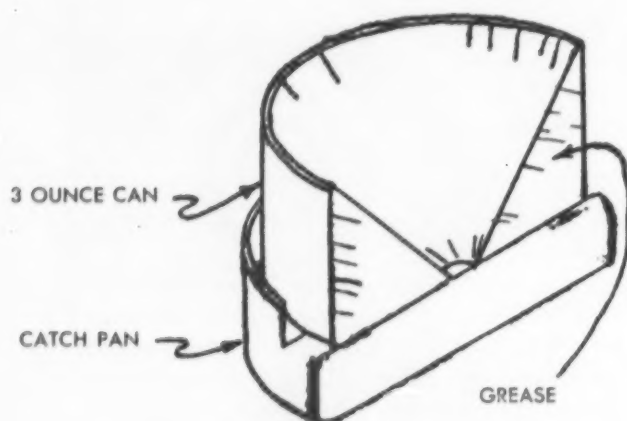


Figure 4—Above, Cross Sectional View of Crater Test Apparatus

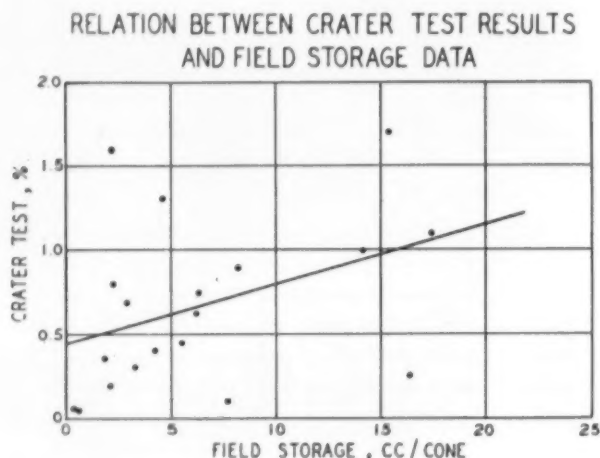


Figure 6

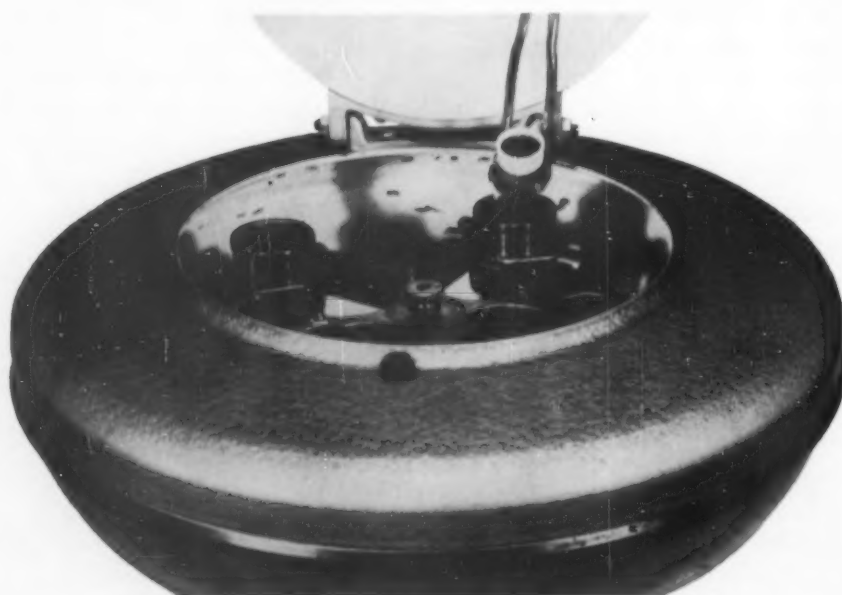


Figure 5—
Centrifugal Filtration Test

Figure 7

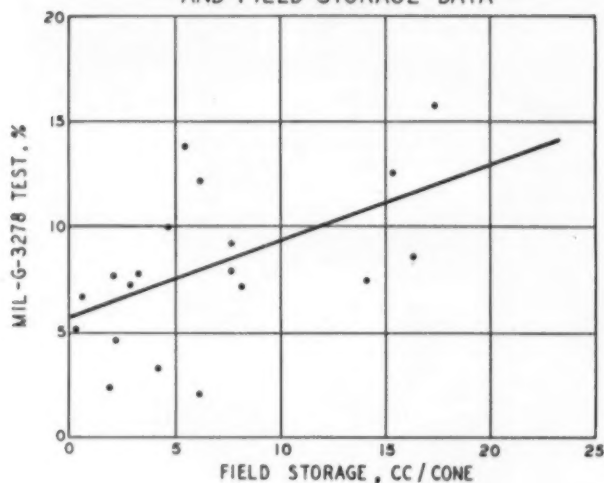
RELATION BETWEEN MIL-G-3278 TEST RESULTS
AND FIELD STORAGE DATA

Figure 8

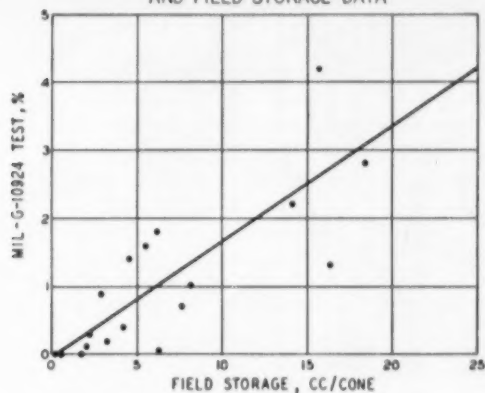
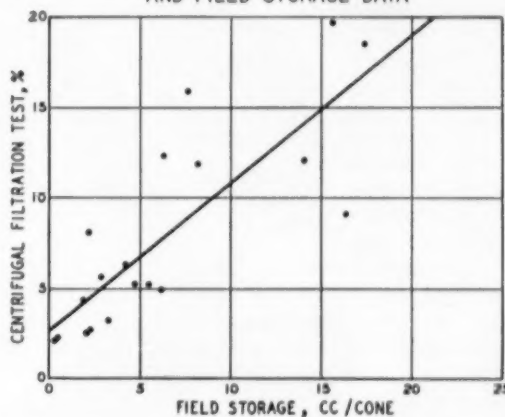
RELATION BETWEEN MIL-G-10924 (AMENDMENT 2) TEST RESULTS
AND FIELD STORAGE DATARELATION BETWEEN CENTRIFUGAL FILTRATION TEST RESULTS
AND FIELD STORAGE DATA

Figure 9

TABLE I
Results of Bleeding Tests

Grease No.	Field Storage (cc/cone)	Crater (% wt. loss)	MIL-G-3278 (% wt. loss)	MIL-G-10924 (Amend. 2) (% wt. loss)	Centrifugal Filtration (% wt. loss)
1	0.3	0.06	5.2	0.0	2.1
2	0.6	0.04	6.7	0.0	2.3
3	1.9	0.35	2.4	0.0	4.4
4	2.1	0.2	7.7	0.1	2.6
5	2.2	1.6	4.6	0.3	8.1
6	2.3	0.8	9.1	6.7	2.7
7	2.9	0.7	7.3	0.9	5.7
8	3.3	0.3	7.8	0.2	3.2
9	4.2	0.4	3.3	0.4	6.3
10	4.6	1.3	10.0	1.4	5.1
11	5.5	0.45	13.8	1.6	5.2
12	6.2	0.65	12.2	1.8	4.9
13	6.3	0.75	2.1	0.05	12.3
14	7.7	0.1	7.9	0.7	15.9
15	8.2	0.9	7.2	1.0	11.9
16	14.1	1.0	7.4	2.2	12.1
17	15.4	1.7	12.6	4.2	19.7
18	16.4	0.25	8.6	1.3	9.1
19	17.4	1.1	15.8	2.8	18.5

TABLE II
Physical Properties of Test Greases

Grease No.	Soap		Type	Oil Properties		ASTM Dropping Point, °F	ASTM Worked Penetration
	Base	Per Cent		SSU at 100°F	Viscosity Index		
1	Sodium	12	Mineral	900	86	500	250
2	Sodium	12	Mineral	620	86	500	250
3	Sodium	14	Mineral	1320	40	410	280
4	Sodium	9	Mineral	900	86	500	290
5	Lithium-Calcium	15	Mineral	150	60	380	275
6	Calcium	12	Mineral	1955	60	200	330
7	Lithium-Calcium	10	Mineral	1090	60	345	295
8	Sodium	9	Mineral	500	86	500	290
9	Sodium	28	Mineral	500	86	450	277
10	Sodium	18	Mineral	413	10	335	315
11	Sodium	8	Mineral	900	86	480	345
12	Sodium	8	Mineral	500	86	480	345
13	Lithium-Calcium	20	Diester-Mineral	58	100	380	285
14	Lithium-Barium	14	Mineral	450	88	380	293
15	Sodium-Calcium	12	Mineral	280	75	360	315
16	Lithium	8	Mineral	480	56	375	284
17	Sodium	9	Mineral	330	50	295	311
18	Lithium	8	Mineral	700	19	375	287
19	Lithium-Barium	12	Mineral	450	88	375	336

Discussion

Four criteria are important in the selection of a laboratory bleeding test. The test should (1) rank a given series of greases in accordance with field storage results, (2) have a suitable sensitivity, (3) require a small sample, and (4) be short and easy to run.

The ability of the four laboratory tests to rank the test greases in accordance with field storage results was determined by the rank correlation coefficient.³ The equation is

$$r = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

where r = correlation coefficient,

d = difference between the rank numbers established by the laboratory and field storage results, and

n = number of test greases.

If the correlation is perfect, $\sum d^2$ is zero and the coefficient is one; if the correlation is very poor, the coefficient will be close to zero. The correlation coefficients determined from these experiments for the four laboratory tests are given in Table III.

TABLE III
Correlation Coefficients of Laboratory Bleeding Tests

Test	Correlation Coefficient
Crater	0.46
MIL-G-3278	0.56
MIL-G-10924 (Amendment 2)	0.80
Centrifugal Filtration	0.85

The results from Grease No. 6 were not included in the calculation of the coefficients for the MIL-G-3278 and MIL-G-10924 (Amendment 2) bleeding tests because the temperatures at which these two tests are run (210°F and 160°F, respectively) are too high for conventional calcium base greases. The inclusion of the results of the calcium base grease in the calculations would have decreased the coefficients of these two tests.

On the basis of the correlation coefficients, the Centrifugal Filtration Test is slightly superior to the MIL-G-10924 (Amendment 2) Test, and both are markedly superior to the other two tests.

The sensitivity of the laboratory tests can be judged by an examination of the results in Table I. The spread between the lowest and highest results of the MIL-G-10924 (Amendment 2) Test is less than that of the Centrifugal Filtration Test. Statistically, an indication of the sensitivity can be obtained by the following equation³ derived on the basis of functionally related variables:

$$S = \frac{K}{\delta}$$

in which S = sensitivity,

K = slope of the line relating laboratory and field results, with the latter plotted as the abscissa, and

δ = standard deviation of the laboratory test results.

The standard deviations of the MIL-G-10924 (Amendment 2) and Centrifugal Filtration Tests were 0.23 and

Continued on page 38

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Acheson to Commemorate 100th Anniversary of Dr. Edward Goodrich Acheson's Birth

In tribute to the memory of Dr. Edward Goodrich Acheson, the 100th anniversary birthday of the founder of Acheson Colloids Company, Port Huron, Mich., will be celebrated by the closing of the Company's plants and offices on March 9, 1956.

The importance of this date, not only to Acheson Colloids Company and other units of Acheson Industries, Inc., but to the entire world, is indicated by two simple references: Webster's New International Dictionary reads, "Acheson, Edward Goodrich. American Inventor. (Carborundum.) 1856-1931"; and the other, made on Acheson's death by another American inventor, Thomas A. Edison: "As a former associate I know the world loses a great genius."

Acheson's first great invention was silicon carbide, which he called "Carborundum," a hard abrasive material that worked so well in metal-shaping that it was

one of the major contributing factors in the growth of mass production, responsible for America's industrial and agricultural revolution.

Later, Acheson's genius made an equally great contribution with the discovery of a process to manufacture graphite. This material, one of Nature's softest solids, was made by Acheson with extremely high temperatures by a process similar to that which gave him silicon carbide (which rivals the diamond in hardness).

From his experiments with graphite came Acheson's discovery of a method to render it colloidal. "Aquadag," colloidal graphite dispersed in water, was first prepared in 1906. Shortly afterwards, "Oildag," a colloidal graphite dispersion in petroleum oil, appeared. Together they opened a new era in industrial lubrication and secured Dr. Acheson's role as one of the pioneers of our modern industrial world.

Comparison of Laboratory and Field Bleeding Tests

Continued from page 36

0.65, respectively. Using the above equation, the sensitivity of the MIL-G-10924 (Amendment 2) Test is 0.7 and that of the Centrifugal Filtration Test is 1.3, indicating that the latter test is the more sensitive. The sensitivity of the other two bleeding tests was not calculated because of their poor correlation coefficients.

By the third and fourth criteria, the Centrifugal Filtration Test is preferred. Of the four tests studied, it takes the shortest time, uses the smallest sample, and does not require any unusual equipment.

In conclusion, it appears that increased pressure is better than increased temperature for accelerating oil separation in the laboratory evaluation of bleeding tendencies

of lubricating greases. The Centrifugal Filtration Test was found to be superior to the three tests which use elevated temperatures. Because it is run at 75°F, the new test is not limited to high melting greases. The adoption of a pressure filtration type of test in place of the usual bleeding tests, which use elevated temperatures, should result in improved lubricating grease specifications and give greater assurance of procuring satisfactory greases.

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3. Mandel, J., and Stichler, R. D., J. Research Nat. Bur. Standards, 53, (3), 155 (1954)



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Patents and Developments

Grease Having Anti-Wear Characteristics

The incorporation of a stabilized dispersion of calcium oxide or hydroxide to enhance the anti-wear characteristics of an aluminum soap base grease is described in the California Research Corporation patent 2,719,826. The dispersion is stabilized by a polyvalent metal sulfonate, such as calcium petroleum sulfonate.

Aluminum soap thickened greases are beneficially used where it is essential to have grease compositions of high water resistance. Normal aluminum soaps (e. g., aluminum stearate) have a mild resistance to emulsification in water, but the normal aluminum soap greases are not beneficially used at high temperatures, such as above 160°F. Particularly effective aluminum soaps which can be used to produce grease compositions having combined characteristics of high water-resistance and high melting points are the complex aluminum soaps, e. g., basic aluminum benzoate stearate.

By "complex basic aluminum soaps" is meant that the aluminum soap molecule contains at least one hydroxyl anion for each aluminum cation, and at least two dissimilar anions substantially hydrocarbonaceous in character.

By "substantially hydrocarbonaceous anions" is meant those anions which are composed mainly of hydrogen

and carbon, and include such anions which contain, in addition minor amounts of substituents such as oxygen, nitrogen, etc.

The organo anions of the complex aluminum soaps are generally oleophilic (i.e., groups derived from or residues of acids, which are oil-soluble); however, one of the organo anions has a greater solubility in lubricating oil than another organo anion. The organo anions of greater oil solubility are designated as "relatively oleophilic" anions, and the organo anions of lesser oil solubility are designated as "relatively oleophobic" anions.

In order to characterize further the organo anions of the aluminum soaps, characteristic properties of each of the organo anions are noted as follows: (i.e., the aluminum di-soaps of the oleophilic anion and the aluminum di-soaps of the oleophobic anion) are insoluble in water. For example, in the aluminum-benzoate-stearate example of this invention, the aluminum di-soap of the benzoate anion (i.e., aluminum di-benzoate) and the aluminum di-soap of the stearate anion (i.e., aluminum di-stearate) are insoluble in water.

The aluminum di-soaps of the more soluble organo anions (i.e., the relatively oleophilic anions) are soluble in a petroleum hydrocarbon lubricating oil (e.g., a California solvent-refined paraffinic oil having a viscosity of

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485 SSU at 100°F.) in an amount of at least 5% at 400°F. That is, at 400°F., 5% of the aluminum soap of the oleophilic organo anion will form a true solution in a petroleum hydrocarbon lubricating oil. On the other hand, the aluminum soaps of the less soluble organo anions (i.e., the relatively oleophobic anions) are soluble in a petroleum hydrocarbon lubricating oil in an amount of less than 1% at 400°F. That is, at 400°F., less than 1% (from 0% to about 1%) of aluminum soap containing the oleophobic anions will dissolve in a petroleum hydrocarbon lubricating oil to form a true solution.

Furthermore, the aluminum soaps of the relatively oleophobic anions melt at a temperature above 400°F., and the aluminum soaps of the relatively oleophilic anions melt at a temperature less than 350°F.

The complex aluminum soaps of this patent are polymeric in structure, that is, the complex aluminum soaps have more than one aluminum atom and at least two dissimilar organo anions throughout the polymeric structure. It is possible for the complex aluminum soaps to contain as many as 1,000 or more monomeric units, each monomeric unit containing one aluminum atom having all of its valences satisfied by at least one hydroxyl group and two organo anions. Thus, it is readily understood that although aluminum has a valence of +3, it is not meant to limit the complex aluminum soap to one containing only three specific anions. In the over-all average, the valence bonds of the aluminum atoms can be directed

to more than three specific anions, that is, to more than one hydroxyl anion and more than two organo anions. The average molecule in the soap may contain a plurality of relatively oleophilic anions or a plurality of relatively oleophobic anions per aluminum atom. For example, it may be advantageous in some instances to use a complex aluminum soap as exemplified by aluminum benzoate-stearate-caprylate.

Suitable relatively oleophilic anions are anions of aliphatic (saturated and unsaturated), aromatic, aralkyl, and cycloaliphatic carboxylic acids. The acids must be sufficiently hydrocarbonaceous in character to impart the desired oil solubility. Thus, the aliphatic (saturated and unsaturated) carboxylic acids may contain from 8 to about 30 carbon atoms, preferably from 12 to 18 carbon atoms. The aliphatic substituent in the various cyclic carboxylic acids may contain at least 4 carbon atoms on the aliphatic group attached to the ring. The aralkyl, alkaryl and cycloaliphatic carboxylic acids preferably contain a total of about 16 carbon atoms. The relatively oleophilic anion may be an alkyl phenol containing at least 4 carbon atoms in the alkyl group, preferably 15 carbon atoms in the alkyl group; e.g., cetyl phenol. It is preferred that the organo-substituted acids of sulfur and phosphorus contain at least 13 carbon atoms, and more especially at least 20 carbon atoms, in the organo substituent. The oleophilic acid anions may contain various substituents, such as hydroxy, amino, alkoxy, e.g., me-

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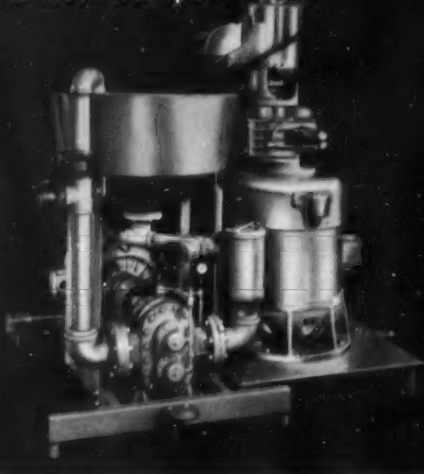


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thoxy and like radicals, so long as the anion remains substantially hydrocarbonaceous in character.

Examples of the carboxylic acids from which the oleophilic anions are derived are: caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, 12-hydroxy stearic acid, arachidic acid, melissic acid, oleic acid, linoleic acid, butyl benzoic acid, hexyl benzoic acid, octyl benzoic acid, dodecyl benzoic acid, phenyl butyric acid, phenyl hexanoic acid, phenyl decanoic acid, cetyl benzene sulfonic acid, a di-dodecyl benzene sulfonic acid (e.g., a di-polypropylene benzene sulfonic acid), an alkane phosphonic acid having at least 24 carbon atoms in the alkane group, cetyl thiophosphoric acid, naphthenic acid, etc. Of these, stearic acid, hydroxy stearic acids, naphthenic acids of molecular weight above about 250, and alkyl benzene sulfonic acids having at least 20 carbon atoms in the alkyl substituents are preferred.

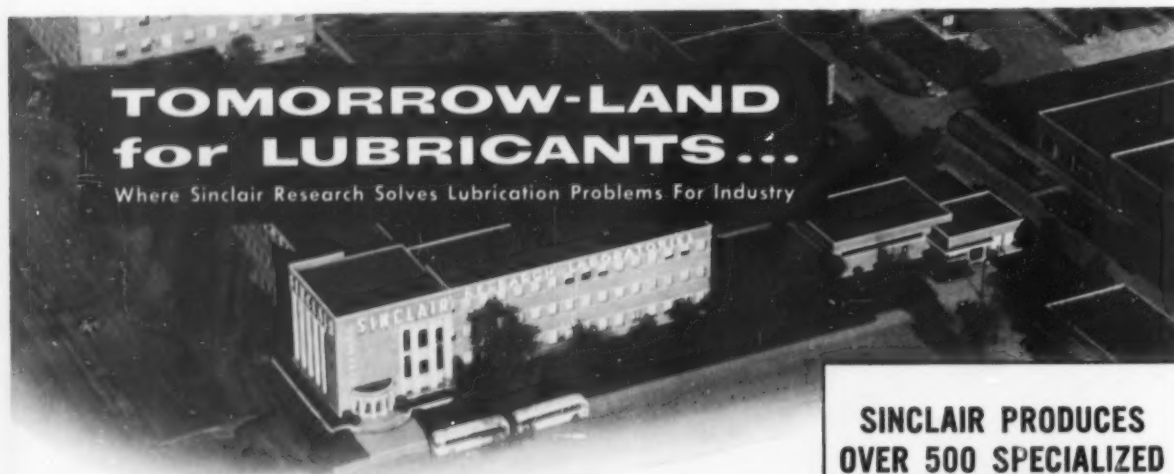
The relatively oleophobic anions are substantially hydrocarbon in structure and may be selected from anions or aliphatic (saturated and unsaturated), aromatic, aralkyl, alkaryl and cycloaliphatic mono- and polycarboxylic acids. Acids having up to two carboxyl groups are preferred, the monocarboxylic acids being especially preferred. For the desired properties, aliphatic monocarboxylic acids of 4 to 7 carbon atoms are employed. When the carboxylic acid contains 2 carboxyl groups, the acid contains from 8 to 11 carbon atoms, and in some cases up to 20 carbon atoms, so long as the anion resulting

therefrom is relatively oleophobic as compared to the oleophilic anion employed. The alkyl groups of the aralkyl and alkaryl carboxylic acids contain no more than 3 carbon atoms. Thus, the alkaryl and the aralkyl carboxylic acids contain a total of not more than 9 carbon atoms, preferably a total of 7 carbon atoms.

Suitable oleophobic anions are derived from benzoic acid, methyl benzoic acid, ethyl benzoic acid, toluic acid, phenyl acetic acid, phenyl propionic acid, suberic acid, azelaic acid, sebacic acid, phthalic acid, salicylic acid, carboxy methyl cellulose, polyacrylic acid, etc. Of these, the benzoic, azelaic and toluic acids are preferred.

Examples of aluminum soaps which are effective thickening agents for grease compositions according to this patent include aluminum laurate, aluminum oleate, aluminum stearate, aluminum benzoate stearate, aluminum benzoate oleate, aluminum benzoate 12-hydroxy stearate, aluminum toluate stearate, aluminum benzoate naphthenate, aluminum benzoate hydrogenated rosin, aluminum benzoate sulfonate, aluminum azelate stearate, aluminum phosphate benzoate stearate, aluminum benzoate hydroxy stearate, etc.

Polyvalent metal sulfonates are used to stabilize the dispersions of calcium oxide and hydroxide. These polyvalent metal sulfonate dispersants include calcium and barium salts of sulfonic acids derived from petroleum, polypropylene, polybutylene, and benzene or naphtha-



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lene alkylated with high molecular weight, oil-soluble hydrocarbon groups. The molecular weight of the hydrocarbon used in the preparation of the sulfonic acid ranges from about 350 to about 900. By "petroleum sulfonate" is meant the mahogany sulfonates, as described in U. S. Patent 2,450,633.

The dispersants (i.e., the polyvalent metal sulfonates) are used in amounts of 0.1% to 10% by weight of the total composition. However, because grease compositions containing from 0.3% to 2% of the dispersants markedly improve anti-wear characteristics, it is preferred to use these latter amounts. The amount of calcium oxide and hydroxide which can be stably dispersed in the lubricating oil depends upon the effectiveness of the particular dispersants used. On a percentage basis depending on the particular dispersant used, from 0.02% to 7% by weight of oxide or hydroxide can be dispersed in the lubricating oil composition.

In addition to the above considerations, the type of base oil of the grease will influence the amount of calcium oxide and hydroxide which is dispersible in the oil. For example, a polyvalent metal sulfonate is more soluble in a base oil of high aromatic or naphthenic content than in a base oil having only a minor aromatic or naphthenic content. Therefore, a greater amount of calcium oxide or hydroxide can be dispersed in an oil of high aromatic content.

In preparing the grease compositions of this patent it is preferred to initially prepare a stable dispersion of

calcium oxide or hydroxide in a lubricating oil. This dispersion of calcium oxide and/or hydroxide in lubricating oil is then incorporated into an aluminum soap-thickened grease in amounts sufficient to enhance the anti-wear characteristics of the aluminum soap greases.

The dispersion of calcium oxide and/or hydroxide in lubricating oil can be prepared by the method outlined in Patent No. 2,676,928. That is, colloidal dispersions (colloidal solutions) of calcium oxide and/or hydroxide in lubricating oils can be obtained by the use of dihydric alcohols, e.g., ethylene glycol. Calcium oxide or hydroxide is dissolved (or dispersed) in a dihydric alcohol. The dihydric alcohol solution (or dispersion) is then thoroughly blended with lubricating oil to form a dispersion of calcium oxide or hydroxide in lubricating oil, which dispersion is then stabilized by a dispersant (e.g., a polyvalent metal sulfonate). The dihydric alcohol is removed by distillation, and the mixture is filtered to remove undispersed calcium oxide or hydroxide.

The filtration rate of dispersions of calcium oxide or hydroxide in lubricating oils can be increased by the use of alpha-hydroxy acids (e.g., glycolic acid, lactic acid, etc.) (or the calcium salts of these acids) in the preparation of the dispersions.

It is desirable that the alpha-hydroxy acids (or the calcium salts thereof) be present in an amount such that the mol ratio of alpha-hydroxy acids (or the calcium salts thereof) to the calcium oxide (or hydroxide) dispersed has a value from about 0.1 to about 4.0.



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Actual Free Fatty Acid Content	90%
Saponification No.	120-130
Free Inorganic Acid	0.2% max.
Iodine Value	20-40
Apparent Solidification Point (titre)	Approx. 44° C.
Softening Point	45-48° C.
% Sulfur	No corrosive sulfur

A.O.C.S. Methods

The grease compositions of this patent can be prepared in the usual manner; for example, an aluminum soap and a lubricating oil can be heated, with agitations, then cooled to room temperature and the stabilized dispersion of calcium oxide and/or hydroxide in a lubricating oil can be incorporated into the aluminum soap grease. On the other hand, a stabilized dispersion of calcium oxide and/or hydroxide in oil may be incorporated into the grease prior to the heating step.

Lithium Soap—Synthetic Base Instrument Grease

The texture-stable lithium base grease claimed to have superior low temperature properties, in which the oil component is a mixture of an aliphatic diester and a mineral oil, is described in U. S. Patent 2,721,844 issued to The Texas Company.

Greases suitable for the lubrication of high speed ball and roller bearings over a temperature range from about 300°F. to about -67°F. have been developed employing aliphatic diesters of high molecular weight as the oil component with lithium soaps. The aliphatic diesters used for this purpose have been ordinarily those within the viscosity range from about 10 to 15 centistokes at 100°F., such as di-2-ethylhexyl sebacate. They have been employed either as the sole lubricating oil component of the grease or in admixture with very low-pour point mineral lubricating oils, usually within the viscosity range of about 5 to 10 centistokes at 100°F., such as were employed as the oil component of low temperature greases before the development of these synthetic oils. A very superior grease of this type having exceptional shear-resistance properties is claimed to be described in U. S. 2,450,222, wherein the lithium soap is obtained from a hydroxy fatty acid material, which is most suitably a mixture of hydrogenated castor oil and stearic acid in about 3:1 proportion by weight.

However, greases of the above type which have been proposed heretofore are said to be not suitable for use at temperatures down to -100°F., as required for the lubrication of the newer types of military aircraft, and it has not been possible to formulate satisfactorily a grease meeting the requirements of the new proposed government specification for a low-temperature grease for this type of service from the teachings of the prior art. Greases wherein the oil component is an aliphatic diester within the viscosity range from about 10 to 15 centistokes, as have been ordinarily employed heretofore, have too high low temperature torques and apparent viscosities at -100°F. to meet the requirements of this specification. When less viscous esters, having viscosities at 100°F. below about 10 centistokes, are employed as the sole oil component of these greases, either an excessively large amount of the very expensive lithium soap or a "structure modifier" of the high polymer type must be employed in order to obtain a grease of satisfactory body and stability. The use of such high polymeric materials is undesirable in greases of this type because of the tendency of polymer additive oils to break down under high shearing stress. Blends of aliphatic diesters and mineral lubricating oils such as have been proposed heretofore are unsuitable for producing greases to meet the new specifications because of unsatisfactory high

and/or low temperature characteristics which they impart to the greases.

According to the patent, it has been now found that very satisfactory greases for the lubrication of aircraft accessories down to -100°F. and meeting all the requirements of the new proposed specification for such low temperature greases are obtained by employing a lithium soap of a soap-forming hydroxy fatty acid with an oil component which is a mixture of a relatively low viscosity aliphatic diester, having a viscosity of 100°F. below about 10 centistokes, and a small proportion of a much higher viscosity mineral lubricating oil. It was found surprisingly that, by the use of small proportions of relatively high viscosity mineral lubricating oils in combination with such diesters, the amount of lithium soap required to produce a grease of a given grade is very greatly reduced, and the greases obtained have lubricating properties which are unexpectedly superior to those wherein the diester comprises the sole oil component.

In accordance with the patent a shear-resistant lubricating grease suitable for use in the lubrication of high speed ball and roller bearings at temperatures down to -100°F. comprises a liquid lubricating oil base consisting of a major proportion of an oil-soluble high-boiling dicarboxylic acid ester of lubricating characteristics having a viscosity within the range of preferably about 7 to 9 centistokes at 100°F., with a minor amount of a mineral lubricating oil having a viscosity within the range from about 14 to 30 centistokes at 100°F., thickened to a grease consistency with a lithium soap, the acid component of which comprises at least a major proportion of a hydroxy fatty acid. The composition is preferably slightly alkaline with about 0.05 to 1.0 per cent of free alkalinity calculated as lithium hydroxide. It also preferably contains a small but effective amount of an oxidation inhibitor such as is commonly employed to inhibit the oxidation of greases in the presence of metals including copper. Amine type oxidation inhibitors, such as for example diphenylamine, are particularly suitable. Various other lubricant additives such as extreme pressure agents may also be present.

The aliphatic diesters which are employed as the major oil component in the above compositions are preferably branched chain diesters of adipic, azelaic or sebacic acids, obtained by reacting these acids with suitable branched chain or secondary alcohols, as for example di-2-ethylbutyl azelate, di-2-ethylhexyl adipate, di-1-ethylpropyl sebacate and so forth. Di-secondary amyl sebacate is a particularly suitable material of this character.

The mineral lubricating oil may be a naphthenic, paraffinic or mixed base oil obtained by any of the conventional refining procedures. It is suitably a lightly refined paraffin base distillate oil, preferably within the viscosity range of about 18-27 centistokes at 100°F. It may comprise preferably about 5 to 8 per cent, by weight of the grease composition.

The lithium soaps are suitably those described in U. S. 2,450,222, obtained from soap-forming fatty materials consisting of more than 50 per cent by weight of hydroxy soap-forming fatty materials selected from the group consisting of hydroxy fatty acids and hydroxy fatty acid glycerides. The hydroxy fatty acids are those

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containing at least 12 carbon atoms in the molecule and one or more hydroxyl groups, as well as mixtures thereof. The soap-forming fatty materials preferably consist of a major proportion of hydrogenated castor oil and a minor proportion of a saturated soap-forming fatty acid such as stearic acid, a mixture of hydrogenated castor oil and stearic acid in about a 3:1 proportion by weight being particularly suitable for forming the lithium soaps for use in the grease compositions of our invention. The lithium soap may comprise preferably about 14 to 18 per cent by weight of the grease composition.

The following example is illustrative of preparation of a grease according to the above patent:

The kettle was charged with 10.8 pounds of 10.2 per cent lithium hydroxide solution, 5.0 pounds of water, 9.0 pounds of hydrogenated castor oil and 5.0 pounds of mineral oil. The hydrogenated castor oil was the same as that employed in Example 2. The mineral oil was a moderately refined paraffinic distillate oil having a flash point, COC, of 400°F., a fire point, COC, of 445°F., a pour point of 20°F. and a kinematic viscosity at 100°F. of 20.7 centistokes. The kettle contents were heated at 180-200°F. with stirring for 4 hours and 2.9 pounds of tripe pressed stearic acid added. The temperature was

maintained at 180-200°F. for an additional 1 hour and the kettle then shut down for 15 hours. The mixture was reheated to 300-320 and maintained at this temperature with stirring for 4 hours to complete the dehydration, and the temperature then allowed to drop. At approximately 320-190°F. 57.5 pounds of di-secondary amyl sebacate were added. When the temperature of the mass was about 200° F. 0.4 pound of a commercial oxidation inhibitor was added. About 0.002 pound of Aniline Yellow dye was also added at about this temperature. The grease was finally drawn at a temperature of 180° F. and pumped through three 60 mesh screens. The product was a light colored buttery grease having essentially the following calculated composition by weight:

	Per Cent
Lithium soap (75% hydroxy stearic acid, 25% stearic acid)	15.6
Glycerine	1.2
Mineral Oil	6.6
Di-secondary amyl sebacate	75.9
Oxidation inhibitor	0.5
Excess LiOH	0.2

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PEOPLE in the Industry

EMERY ANNOUNCES PERSONNEL



N. A. RUSTON

N. A. Ruston, Director of Development and Service for Emery Industries, Inc., retired February 1 after 26 years service. In accepting Mr. Ruston's request, A. W. Schubert, executive vice president, also announced that Mr. Ruston will continue to serve the company in a consulting capacity because of his long experience in the industry and his extensive technical knowledge.

Succeeding Mr. Ruston will be W. T. Meinert who has been assistant director of the department. As director he will be responsible for the market development of all new products and technical service activities relating to Emery's complete line of fatty acids, special acids and derivatives, plasti-



W. T. MEINERT

cizers and textile products.

Mr. Ruston joined Emery in 1930 as a salesman, progressing to general sales manager and subsequently to the position he is now leaving. For the past 14 years he has also been a director of the company. He is well known throughout the industry and has participated actively in many trade associations.

His successor, Mr. Meinert, joined Emery's Development and Service Department seven years ago after considerable field experience, particularly in the textile processing field. He holds a B. S. degree in Chemistry from St. Ambrose College, Davenport, Iowa, and a M. S. degree from the Institute of Textile Technology



R. G. KELSO

in Charlottesville, Va. He is active in the American Chemical Society, American Association of Textile Chemists and Colorists and the American Oil Chemists' Society.

R. G. Kelso and Richard H. Proctor have joined the sales staff of the Chemical Division of Emery Industries, Inc., it is announced by R. F. Brown, chemical sales manager. After completing an orientation and training course they will be assigned to the field sales organization.

Mr. Kelso holds a B. S. degree in Chemistry and an A. B. degree in English from Morris Harvey College, Charleston, W. Va. After graduating he became associated with Carbide &

CONTINENTAL CAN EXECUTIVES RECEIVE PROMOTIONS

In a reorganization of personnel in the Metal Division of Continental Can Company, necessitated by substantial sales increases and recent retirements, the following staff changes, effective March 1, have been announced by Reubin L. Perin, executive vice president of the division.

L. Ylvisaker has been promoted from director of staff for the Metal Division, in New York, to general manager of the Metal Division Research and Development Department, Chicago. E. L. Hazard, now general

manager of the northeastern district of the Eastern division, will become director of staff.

W. K. Neuman, now general manager of sales, has been appointed manager of new products. R. S. Hatfield, now general manager of the north central district of the Central division, Chicago, is appointed general manager of sales. Mr. Neuman and Mr. Hatfield will make their headquarters in New York.

In the Eastern division, R. D. Heaviside, formerly district sales

manager in Baltimore, has been appointed general manager of the northeastern district, New York; S. M. Bixler, previously plant manager at Harvey, Louisiana, becomes general manager of the midwestern district, Baltimore; J. S. Devlin, formerly Houston district sales manager, is now general manager of the southeastern district, New Orleans. The latter two appointments are effective immediately.

In the Pacific division, C. F. Marquard, previously manager of produc-

CHANGES



R. H. PROCTOR

Carbon's Research Laboratories in South Charleston, later transferring to technical sales where he remained until joining Emery. He is a member of the American Chemical Society, American Association of Textile Chemists and Colorists, Cincinnati Paint, Varnish and Lacquer Association and the Appalachian Geological Society.

Mr. Proctor has a B. S. degree in Chemistry from Ohio University. After graduating in 1951 he joined Koppers Company and became a group leader in that company's Monaca, Pa., laboratories. Immediately prior to joining Emery he was with Fischer Scientific Company in a sales capacity.

tion engineering for the Central division, has been named general manager of the south Pacific district, San Francisco; J. W. Broomhead, heretofore plant manager at Pittsburgh, has become general manager of the north Pacific district, Portland, Oregon.

All of these personnel changes have taken place from within the Continental Can Company organization itself, for it is the company policy, wherever possible, to promote men who are experienced Continental employees.

Larson Joins Climax Chemical Research Staff

Melvin Larson has joined Climax Molybdenum Company as a research chemist at its Detroit Research Laboratories.

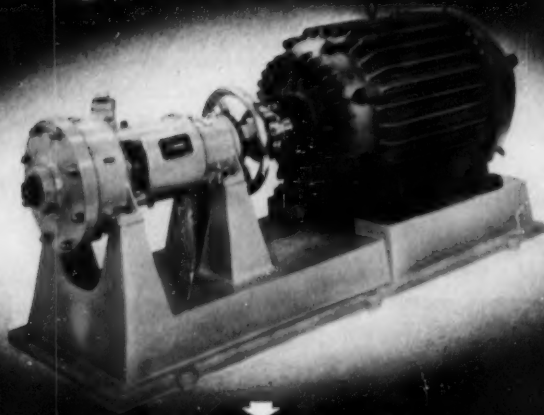
Previously Mr. Larson had been with Ethyl Corporation for three and a half years conducting organo-metallic research related to anti-knock additives for gasoline. At Climax, he will work on the synthesis of new organic derivatives of molybdenum

and the investigation of their properties and potential uses.

Mr. Larson has a B. S. degree (1950) from Augustana College, Sioux Falls, South Dakota, and an M. S. degree (1952) from the University of North Dakota. He is a member of Sigma Phi (honorary research organization) and the American Chemical Society.

He served two years with the U. S. Army Signal Corps. He resides in Royal Oak, Michigan, with his wife and two children.

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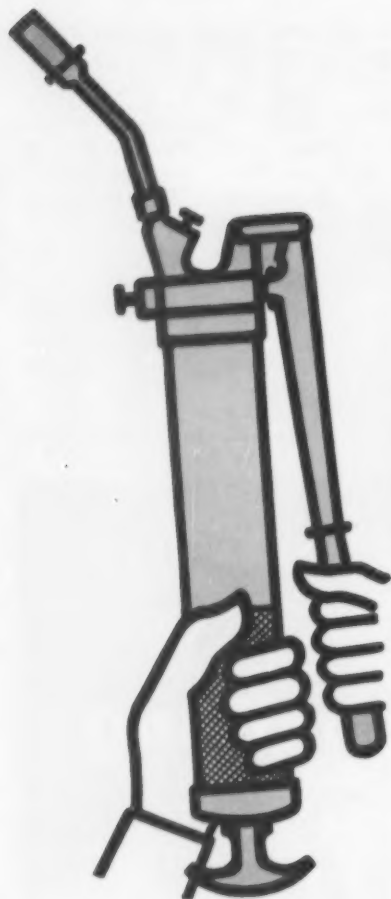
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Foote Mineral Elevates Board Members



G. H. CHAMBERS

Gordon H. Chambers has been named Chairman of the Board of Foote Mineral Company, Philadelphia, Pa., and L. G. Bliss has been elected President at a regular board meeting on Thursday, January 26, 1956. The appointments are to be effective February 1, 1956. Chambers, formerly President, succeeds H. C. Meyer who retired December 31, 1955. Bliss was elevated from Senior Vice President.

In announcing the appointments, the board stated that Chambers would continue to be an active senior officer of the company.

Chambers joined Foote Mineral as a sales engineer shortly following his graduation from the University of Pennsylvania in 1928. He became Vice President in 1936, and President in 1952.



L. G. BLISS

During World War II, Chambers served with U. S. Army Ordnance and rose to the rank of Colonel. Overseas, he served as Deputy General Purchasing Agent of the Armed Forces in Europe. He was seriously wounded during the Normandy invasion of 1945, and returned to active participation in the company's management after two years of convalescence.

L. G. Bliss joined Foote Mineral following the completion of graduate studies in physical chemistry at Rutgers University in 1931. After three year's interim employment with General Chemical Company, Bliss returned to Foote in 1936 and became Sales Manager in 1938. He has served as a board member since 1942 and was elected Vice President-Sales in 1952.

Foote Names W. B. Towner General Production Manager

William B. Towner has been appointed General Production Manager of Foote Mineral Company, and will be directly responsible for the company's three producing units at Exton, Pa., Sunbright, Va., and Kings Mountain, N. C. The former Exton plant manager will report directly to F. B. Shay, Vice President-Production and Engineering.

The newly created position which Towner assumes will not affect the present organization at any of the three local levels. In announcing the appointment, Mr. Shay stated that the

move is expected to bring about a closer, coordination of function between the company's three operating units.

Towner joined Foote Mineral Company in 1943 as chemical plant manager, after 23 years of production experience with General Chemical Division of Allied Chemical & Dye. In 1945 he was appointed plant manager of the firm's Exton plant—a position which he has held until the present.

At the Exton plant, Towner was responsible for the operation of the company's lithium pilot plant, which



W. B. TOWNER

was the forerunner and small scale model of the later Sunbright plant. He has been responsible for many of the engineering developments which made the larger operation possible and has been intimately associated with the company's unique spodumeno-line process since its inception.

A native of Baltimore, Md., Towner attended Baltimore Polytechnic Institute and Johns Hopkins University, majoring in chemistry. A weekend farmer, Towner now lives in suburban West Chester, Pa., near the Exton plant which will remain his headquarters. He is a member of the West Chester Chamber of Commerce.

The vacancy created by Towner's appointment is to be temporarily filled by Eugene Meszaros, plant superintendent, who has been named acting plant manager by Vice President Shay. Meszaros is a resident of Malvern, Pa.

Fentress Named General Sales Manager of Foote Mineral

James Fentress has been named General Sales Manager of Foote Mineral Company, effective February 1, 1956, according to L. G. Bliss, President. Fentress was formerly Director of Economics Planning, and had also served as Manager of Petroleum Sales.

Following his graduation from Princeton in 1943, Fentress joined E. I. DuPont and in a research capacity was active for more than two years on the atomic bomb project. In 1946, he entered Northwestern University



JAMES FENTRESS

and, after completing his graduate studies, continued on until 1952 as a research associate on a U. S. Navy Bureau of Ships project.

Fentress is an active member of the American Chemical Society and the Electrochemical Society. He is a resident of Villanova, Pa.

American Potash Names W. J. Hutchinson a Director

William J. Hutchinson has been named a director of American Potash & Chemical Corporation, it has been announced by Peter Colefax, president. He will fill the vacancy created by the death of William J. Murphy in December of last year.

Hutchinson has been a director of the International Nickel Company of Canada, Ltd., since 1924. He is also a member of the New York local board of the Atlas Assurance Company of London, and a member of the New York board of directors of Prudential Insurance Company, Great Britain.

Born in Montclair, N. J., Hutchinson attended Lehigh University, graduating in 1906.

Climax Retains Consultant J. G. Dean

Dr. John G. Dean, chemical and metallurgical consultant, Tuckahoe, N. Y., has been retained by Climax Molybdenum Company to advise on certain aspects of the company's recently expanded chemical program. This program includes development

of new and expanded applications for molybdenum compounds in catalysis, lubrication, agriculture and pigments as well as research into other fields where molybdenum chemicals are of potential value.

Dr. Dean specializes in the heavy metals, particularly their chemical and catalytic applications in industry and their hydrometallurgical extraction. In addition to acting as a consultant to several large chemical and metal companies, Dr. Dean is associated with Columbia University. He is currently on leave from their Division of Cooperative Research to handle a strategic metal processing program. Previous positions include supervision of research and development related to chemical and catalytic applications of nickel for International Nickel Company; teaching chemistry and physics at Sarah Lawrence College; and director of the laboratory research division of Permutit Company.

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Industry NEWS

Socony Mobil Announces New Earnings High

Socony Mobil earned a little over \$200,000,000 in 1955, according to Albert L. Nickerson, president of the company. He spoke before the New York Society of Security Analysts. Noting that his estimate is not a final figure, since year-end adjustments are not complete, he said:

"Our earnings for 1955 established a new record and presently are estimated at a little over \$200 million, or about \$5.75 a share. This is an increase of roughly 10 per cent over the previous year's earnings of \$184 million, or \$5.25 a share." There was the same number of shares outstanding—34,982,068—in both 1954 and 1955.

The record earnings were attributable to a strong demand for petroleum products throughout the free

world, Mr. Nickerson said, adding that large capital expenditures by the company in recent years "enabled us to take advantage of rising demand." He said that Socony Mobil sales in 1955 rose by 12 per cent in the Eastern Hemisphere and 7 per cent in the Western Hemisphere.

He predicted a five per cent rise in demand for petroleum products in the free world for 1956, estimating a gain of four per cent in the United States and more than seven per cent abroad.

The world-wide capital expenditures of Socony Mobil in the last ten years (1946-1955) have amounted to about \$2 billion 200 million, Mr. Nickerson said. Roughly 60 per cent of this money was spent for production. In 1946, the company's world-wide production was 234,000 barrels of crude oil a day; in 1955, it was 579,000 barrels daily. Its world-wide daily refinery runs during that period rose from an average of 424,000 barrels to 724,000 barrels.

World-wide capital expenditures scheduled by the company for 1956, he said, amount to a record \$419 million. Slightly more than half of this will be spent for producing activities. About \$354 million of the total will be spent in the Western Hemisphere, he said, and the remaining \$65 million in the Eastern Hemisphere. He pointed out that the latter amount was not a full reflection of Socony Mobil's 1956 capital expenditures in the Eastern Hemisphere since it does not include capital expenditures of companies in that area in which Socony Mobil has an interest of 50 per cent or less.

He added that: "With upwards of \$220 million on hand . . . we see no likelihood that it will be necessary for us either to borrow additional money or to raise more capital by sale of stock in 1956, notwithstanding our record capital expenditure program."

Mr. Nickerson reported that the only area in the United States that provided Socony Mobil with important discoveries of new oil fields was the Gulf of Mexico off Louisiana, where the company's affiliate, Magnolia Petroleum Company, participated in the discovery of seven new

fields.

Mr. Nickerson also announced that, beginning with 1956, Socony Mobil will return to the practice of reporting its earnings on a world-wide consolidated basis. This practice was abandoned at the beginning of World War II. It is possible to reinstate it because more stable economic and currency-exchange conditions now exist in the Eastern Hemisphere.

Monsanto Begins Construction of New Plant

Construction began in Luling, Louisiana, this week on a new plant for the large-scale production of adipic acid representing a major expansion in the product by Monsanto Chemical Company's Organic Chemicals Division.

Located at the Barton Plant of Lion Oil Company, a Division of Monsanto, the new unit is estimated to cost several million dollars and is expected to be on stream early in 1957.

Charles H. Sommer, Monsanto vice president and general manager of the Organic Chemicals Division, said that the plant will be fully integrated with Lion raw materials facilities at the location. First such integration of production to be announced since the Monsanto-Lion merger last September, it is indicative of the advantages inherent in the marriage, Sommer said.

Monsanto has been one of the major U. S. suppliers of adipic acid since January, 1955, when the company first offered the resin intermediate in commercial quantities.

Long used in the manufacture of nylon, adipic acid has come into recent and rapidly expanding use in the manufacture of flexible polyurethane foams for crash pads, seating, carpet underlay and a variety of other cushioning applications.

The reactive dibasic acid also is used to modify surface coating resins, to impart flexibility to vinyls and to improve the flexibility of polyesters. These resins find wide use in casting, molding, laminating, impregnating, bonding, and sealing applications.

Other uses of adipic acid include the manufacture of synthetic lubricants, detergents and textile chemicals.

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Shell Oil Company Reports Estimated 1955 Earnings

Net earnings of Shell Oil Company and subsidiaries for 1955, after taxes, are estimated at \$125,500,000, according to H. S. M. Burns, president. This includes \$6,100,000 realized from the sale of midwestern Shellane bottled gas facilities.

The Shell earnings figure represents \$4.56 per share compared with \$121,127,000 or \$4.41 per share for 1954.

Kerr-McGee Announces Dividend Payments

The board of directors of Kerr-McGee Oil Industries, Inc., announced after a meeting Feb. 7 dividend payments of 28.125 cents per share for the company's prior convertible preferred stock and 15 cents per share for common stock. The dividend payment will be payable April 1 for the quarter ended March 31, to stockholders of record at the close of business March 9.

As of September 30, 1955, Kerr-McGee's outstanding stock consisted of 674,880 shares of convertible preferred and 1,760,893 shares of common. The company has approximately 5,000 shareholders.

Automation Best Seller Overseas!

Books on automation are becoming world-wide best sellers!

The United States Information Agency reports automation is high on the list of the most-asked-for subjects in its overseas libraries. To cope with the interest generated in this typically American technological development the USIA has stepped up its supply of articles, books, pamphlets and motion pictures on the subject.

Representative material comes from American labor leaders, industrialists, scientists and educators. For example, Minneapolis-Honeywell's Industrial Division cooperates by supplying 39 USIA libraries abroad with copies of its technical publication, "Instrumentation." The magazine carries case history studies of how industry applies automation techniques in everything from atomic energy, research, utility plants, heat treating of metals to chocolate processing. The firm's unique "Automation Dictionary" is also distributed to the overseas information centers.

U. S. Steel's Taylor Retires

Myron C. Taylor, formerly chairman of the board and chief executive officer, retired January 13 as a director of United States Steel Corporation.

Announcement of Mr. Taylor's retirement was made by Roger M. Blough, chairman of the board.

Mr. Taylor has served continuously for more than thirty years as a director and member of the finance committee of the corporation. He served as chairman of the finance committee from 1927 to 1934 and was chairman of the board and chief executive officer from 1932 to 1938.

Born in Lyons, New York, Mr. Taylor received his early education in private and public schools and was graduated from Cornell University at the age of twenty with an L.L.B. degree. After specializing in corporation law, Mr. Taylor's interests subsequently spread to the textile and banking fields.

Following his retirement as an officer of United States Steel Corporation in 1938, Mr. Taylor distinguished himself in governmental service, holding the rank of ambassador from 1939 to 1953.

Mr. Taylor is widely known for his work in philanthropies and for gifts for education, religious and other purposes.

Catalytic Reforming Unit Under Construction for Socony

A catalytic reforming unit for upgrading motor gasoline will be built at the East St. Louis, Ill., refinery of Socony Mobil Oil Company, Inc.

Construction of the unit, which will employ the Sovaforming process developed by Socony Mobil, is part of a \$95 million expansion and improvement program scheduled by the company for its 12 United States refineries in 1956.

The Sovaformer will have a rated capacity of 12,000 barrels a day, and will include a pre-treater with a capacity of 16,000 barrels a day. Construction is expected to begin about mid-year, with completion scheduled for early 1957.

A contract for construction has been awarded to the Fluor Corp. of Los Angeles, Calif.

New Sound Slidefilm Guide Lists 20 Oil Titles

Twenty sound slidefilms on practical petroleum topics are described in a new source book, the Sound Slidefilm Guide, published by the DuKane Corporation, St. Charles, Ill.

Source of each filmstrip is noted in the guide along with its availability whether by rental, purchase, or free loan. Priced at \$1.00, the Sound Slidefilm Guide can be ordered from the Audio Visual Division, DuKane Corporation, St. Charles, Ill.

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Du Pont to Develop New Petroleum Additives

Du Pont's Petroleum Chemicals Division has established a new additives sales group to improve customer service and to prepare for new petroleum additives developments, David H. Conklin, directors of sales, announced.

J. J. Mikita, formerly director of Du Pont's Petroleum Laboratory, has been named sales manager of the new additives group with headquarters in Wilmington. His assistant will be W. W. Wingate, formerly in the product development group of the Petroleum Chemicals Division.

W. E. Bettoney, formerly an assistant director of the Petroleum Laboratory, will become manager for additives in the Eastern region with headquarters in New York. N. D. Lawson, who has been head of the fuels and lubricants section of the laboratory, will take over as manager for additives in the Central region, working out of Chicago. J. B. Malin has been named to the new position in the Western region where he has

been regional laboratory manager.

Dr. B. M. Sturgis, formerly assistant director, has been promoted to director of the Petroleum Laboratory. Assistant laboratory directors will be R. O. Bender, in charge of technical service, and R. H. Blaker, handling product evaluation.

Du Pont's Delin Discusses Advertising Assets

"The advertiser deals with the 'three P's,' people, products, and promotion, and the greatest of these is people," said A. L. Delin, advertising manager of the Du Pont Company's Petroleum Chemicals Division.

Mr. Delin, speaking before the Houston Chapter of the National Industrial Advertising Association, said people are a company's greatest asset.

"We sometimes forget that nobody cares how good we think our product is. What the prospect wants to know is the good a product will do him, and when you analyze this a little, you're not selling products at all, you're selling people—a market is not a geographic area, then, it is people," Mr. Delin said.

The best way to know people better is to get to know those close to you, the speaker pointed out. To sell products, you must study people, get to know them well and truly. Study your business associates and employees and apply the same principles for pleasant relationships with these people as with your customers, Mr. Delin said.

"I believe all people, your associates as well as your customers, struggle through life with an imperative urge to satisfy needs," he said.

Mr. Delin then went on to list the three main needs of people as being physical, social, and a desire for recognition. We try to satisfy these needs of our employees so they won't quit, and in like manner we should try to satisfy the needs of our customers so they won't quit using our products, he said.

"It doesn't pay to kick people around, and excessive paternalism doesn't work either. This is as true of our customers as it is of our employees," the Du Pont advertising executive told the group.

Mr. Delin went on to say that for an employee to be happy with his job he must have fun doing it, and so

must customers be shown the enjoyment or profit offered by our products whenever and wherever possible.

"Inspiration from the job is what makes it worth while. And so, too, what we say about our products should inspire our customers if we really want them to buy."

New Metasap Booklet on Metallic Soaps

A new 30-page booklet all about metallic soaps has been published by the Metasap Chemical Company.

One of the features of the booklet is a complete history of metallic soaps, tracing their development from the 18th century to the present day, and describing in detail the role they play in today's industry.

The booklet also gives a complete descriptive listing of Metasap metallic soaps, including physical and chemical characteristics and industrial applications. Metasap, a subsidiary of the Nopco Chemical Company, is a leading manufacturer of metallic soaps for the lubricating grease industry.

A free copy of the Metasap booklet is available by writing to Dept. M, Metasap Chemical Company, Harrison, N. J.

B. F. Fairless Asserts Necessity Of Labor-Saving Machinery

Opponents of labor-saving machinery are short-sighted and misguided, because they lack an understanding that the purpose of America's capitalistic economy is "to provide everyone with maximum goods and services at a minimum amount of labor," asserted Benjamin F. Fairless, chairman of the executive advisory committee of United States Steel Corporation.

When an understanding of that purpose is widely enough achieved, this country can devote its "united thoughts and efforts" to doubling production, with an accompanying rise in the standard of living, while at the same time steadily decreasing hours of labor, Mr. Fairless declared.

Mr. Fairless spoke at the Annual Awards Dinner of "The Moles," an organization of men now and formerly engaged in marine, tunnel, subway, and similar forms of heavy construction. He was installed as an honorary member of "The Moles" by A. Holmes Crimmins, president of the organization.



Almost everything that moves either in actual operation or in the process of its making . . . from gate hinges to tractor wheels . . . depends upon grease. That is why lubricants should be bought with care. You can always depend upon Deep Rock highest quality greases and lubricants. They are manufactured to give top lubrication to all moving parts.



The only way to insure a steadily expanding output and a rising standard of living, with a declining amount of hours and drudgery spent in production, is through the invention and design of machines that will do more work in less time, Mr. Fairless said.

Those who denounce inventors of labor-saving machines as enemies of mankind seem concerned only that men toil, not that they toil fruitfully in producing needed goods and services, he added.

"I sometimes suspect that those persons believe that the best way to encourage prosperity and progress would be to destroy all the bulldozers and go back to moving earth with spades," Mr. Fairless said.

Hand-labor methods can guarantee full employment, as they are now guaranteeing it in Communist China and in Communist Russia where, Mr. Fairless pointed out, "old women sweep the streets of Moscow with crude brooms made from tree branches," but those methods do not provide "adequate food, clothing, housing, medical care, or other necessities and luxuries that people want."

In order to achieve the full potential of a capitalistic economy, a true understanding of it should be coupled with faith in the competitive system of private enterprise and with opposition to "laws and customs that discourage it," Mr. Fairless said.

Faith, the mountain-moving force of the scriptures, is, he continued, an indispensable ingredient of the American enterprise system. A private business or industrial enterprise, he said, must preserve faith in the integrity of its management by always keeping its pledged word, even when that is costly to do.

"We can always build new steel mills and bigger and better bulldozers," Mr. Fairless said. "But it is far more difficult to rebuild a destroyed faith."

Faith in the American political system has given this country stable government, while in some other nations "most of the people have little faith in their governments, and the governors have little faith in the people," Mr. Fairless told the banquet of the heavy-construction and earth-moving organization.

API Announces Committees For 1956

Appointment of functional committees for 1956 has been announced by J. G. Jordan, vice president for the Division of Marketing of the American Petroleum Institute.

The committees and their memberships are as follows:

Lubrication Committee

D. G. Proudfoot, chairman, The Pennzoil Co., Oil City, Pa.; F. E. Rosenstiehl, vice chairman, The Texas Co., New York; G. Harold Osborne, secretary, Kendall Refining Co., Bradford, Pa.; R. T. Agster, United Cooperatives, Inc., Alliance, Ohio; R. C. Alden, Phillips Petroleum Co., Bartlesville, Okla.; A. B. Anglin, The British American Oil Co., Ltd., Toronto, Ontario, Canada; F. H. Ayden, C. C. Wakefield & Co., Ltd., New York; K. C. Baker, J. D. Streitt & Co., Inc., St. Louis, Mo.; Fred G. Bannerot, Jr., Elk Refining Co., Charleston, W. Va.; Paul Boyd, Cities Service Oil Co., New York; U. B. Bray Oil Co., Los Angeles, Calif.; Oscar C. Bridgeman, Phillips Petroleum Co., Bartlesville, Okla.; A. E. Carlin, Crystal Motor Oil Co., Chicago, Ill.; Dayton P. Clark, Gulf Oil Corp., Pittsburgh, Pa.; R. Cubicciotti, L. Sonneborn Sons, Inc., New York; W. D. Cyphers, Lion Oil Co., El Dorado, Ark.; A. J. Daniel, Battenfeld Grease and Oil Corp., Kansas City, Mo.; John E. Dickson, Ashland Oil & Refining Co., Ashland, Ky.; G. T. Dougherty, Standard Oil Co., (Indiana), Chicago, Ill.; Harry A. Erickson, D. A. Stuart Oil Co., Ltd., Chicago, Ill.; H. P. Ferguson, The Standard Oil Co., (Ohio), Cleveland, Ohio; T. E. Fitzgerald, D-X Sunray Oil Co., Tulsa, Okla.; W. R. Gaylord, Standard Oil Co., (Kentucky), Louisville, Ky.; C. W. Georgi, Quaker State Oil Refining Co., Buffalo, N. Y.

M. D. Gjerde, Standard Oil Co., (Indiana), Chicago, Ill.; Hugh L. Hemmingway, The Pure Oil Co., Chicago, Ill.; W. P. Hilliker, Pan-Am Southern Corp., New Orleans, La.; Dart E. Hoffman, Tide Water Associated Oil Co., New York; W. M. Holaday, Socony-Mobil Oil Co., Inc., New York; H. F. Jones, Cities Service Oil Co., Chicago, Ill.; P. W. Judah, Socony Mobil Oil Co., Inc., New York; F. O. Koontz, Quaker State Oil

Refining Corp., Oil City, Pa.; George Landis, The Atlantic Refining Co., Philadelphia, Pa.; C. M. Larson, Sinclair Refining Co., New York; F. I. L. Lawrence, Kendall Refining Co., Bradford, Pa.; A. G. Lawson, McColl-Frontenac Oil Co., Ltd., Montreal, Quebec, Canada; W. T. Leeper, Bayou State Oil Corp., Shreveport, La.; Kenneth G. MacKenzie, Westport, Conn.; William A. Magie II, Magie Bros. Oil Co., Franklin Park, Ill.; Leonard H. McMahon, American Oil Co., New York; G. E. Merkle, Fiske Bros., Refining Co., Newark, N. J.; H. B. Miller, Sunset Oil Co., Los Angeles, Calif.; H. B. Miller, The Ohio Oil Co., Findlay, Ohio;

William M. Murray, Deep Rock Oil Co., Oklahoma City, Oklahoma; G. L. Neely, Standard Oil Co. of California, San Francisco, Calif.; C. R. Noll, Gulf Oil Corp., Pittsburgh, Pa.; G. A. Olsen, Sunland Refining Corp., Fresno, Calif.; F. H. Ott, Union Oil Co. of California, Los Angeles, Calif.; L. F. Paape, Filmit Oil Corp., Milwaukee, Wisc.; J. A. Ransford, Tide Water Associated Oil Co., San Francisco, Calif.; B. E. Rawlings, Cities

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API Issues Management Training Booklet

A new booklet which tells how to organize a "training-for-management" program under the sponsorship of state and local oil marketer associations jointly with a state college or university has been released by the

Marketing Division of the American Petroleum Institute. Entitled "Management Institutes Pay Off!" the booklet explains what management institutes are, how they are sponsored, what subjects are discussed, and what benefits accrue to oil marketers attending these management institutes.

"This booklet was prepared as a service to oil marketers and their associations by the Marketing Division's Personnel Training Committee under chairman Frank R. Markley, vice president in charge of sales, Sun Oil Company, Philadelphia. One of the principal objectives of the booklet is to explain how to organize and conduct a management institute for wholesale and retail oil marketers," A. J. Rumoshosky, Marketing Division director, announced.

Another objective of the booklet, he said, is to familiarize marketing executives at all levels in the industry with the "training-for-management" programs being sponsored by oil marketer associations and the benefits which will be derived both by the oil marketer and the representatives of his supplier through participation in these management training programs. Rumoshosky noted that these management training programs have the endorsement of the National Oil Jobbers Council. He said that the Council is actively cooperating with the API Marketing Division on this project through L. T. White, Cities Service Petroleum, Inc., New York, who is vice chairman of the Marketing Personnel Training Committee.

To provide a solid foundation for future institutes, the booklet draws on the experience and lessons learned from 27 management institutes held since 1952 at 14 colleges and universities in 13 states.

"It is hoped that this booklet will be of help to the secretaries and officers of state and local oil marketer associations in planning, organizing, and getting a good attendance for management institutes sponsored by their own organizations," Rumoshosky said.

These booklets are available free of charge on a first-come, first-serve basis as long as the supply lasts. Requests should be sent to the Division of Marketing, American Petroleum Institute, 50 West 50th Street, New York 20, N. Y.

Battelle Institute Ready Molybdenum Bulletins

A series of technical data bulletins on several classes of molybdenum chemicals is being prepared by Battelle Memorial Institute, Columbus, Ohio, under commission from Climax Molybdenum Company. These bulletins will report the properties, methods of preparation and applications of these compounds:

1. Organic complexes of molybdenum.
2. Molybdenum disulfide.
3. Heteropolymolybdates.
4. Cyanomolybdates.
5. Halides and oxyhalides of molybdenum.

These particular compounds were chosen for inclusion in this new technical series because of current widespread interest in organometallics, sparked by the commercial success of the silicones; in semi-conductors; in formation of large molecules of value, for example, in the organic color field; and in the production of color changes through physical or chemical reactions. Up to now, workers exploring these new fields have had difficulties in locating the necessary basic information on molybdenum compounds likely to be of value to them.

The first of these bulletins will be ready for distribution within a few weeks, and the remainder will follow shortly.

API Publishes "Searching for Oil"

A streamlined, up-to-date version of the popular booklet "Searching for Oil" has been published by the American Petroleum Institute.

The booklet is designed to present to general audiences in swift-paced, readable copy, the facts concerning the physical difficulties and financial risks that oil men must face in their job of keeping America supplied with petroleum. It also reviews the continuing success the petroleum industry nevertheless achieves in finding adequate new oil deposits.

The two-color, 16-page booklet is one of the many public information materials available through the Institute or district offices of the Oil Industry Information Committee. Booklets are \$5.00 per hundred; single copies are free.

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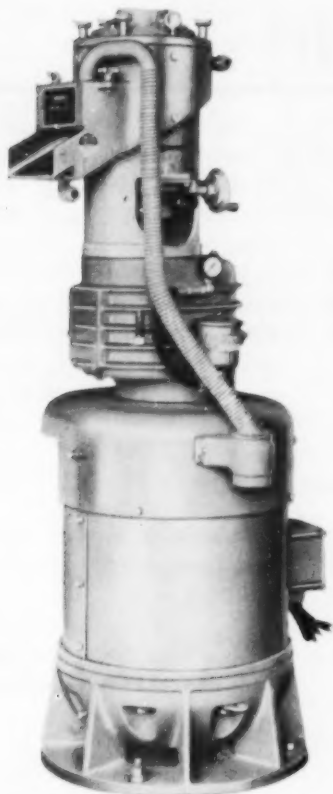
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Morehouse-Cowles Features New Mill Line

A new improved line of Morehouse Mills for the process industries is being featured by Morehouse-Cowles, Inc., National Distributors for Morehouse Mills and Cowles Dissolvers, according to Mr. Donald Grubbs, Vice President and General Manager.

All models of the advanced Morehouse line feature new handwheel adjustment with micrometer setting and positive lock, magnetic swirl arrester that reduces splash and removes tramp metal, built-in stop that indicates time for stone replacement, new easier time-saving method for head and stone removal and replacement, an external grease fitting and other refinements.

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FUTURE MEETINGS of the Industry

MARCH, 1956

- 7-9 American Petroleum Institute (Division of Production, Southern District Meeting), Plaza Hotel, San Antonio, Tex.
- 12-16 National Assn. of Corrosion Engrs. (annual convention), Statler Hotel, New York, N.Y.
- 13-14 Illinois Petroleum Marketers Association (24th annual convention), Sherman Hotel, Chicago, Ill.
- 13-14 Petroleum Packaging Committee, Francis Drake Hotel, San Francisco, California.
- 15-17 Texas Oil Jobbers Association, Statler Hilton Hotel, Dallas, Texas.
- 19-21 Western Petroleum Refiners Association (annual meeting), Plaza Hotel, San Antonio, Tex.
- 20-22 Ohio Petroleum Marketers Assn., Inc. (Spring convention & trade exposition), Deshler Hilton, Columbus, Ohio.
- 21-23 American Petroleum Institute (Division of Production, Southwestern District Meeting), Texas Hotel, Fort Worth, Tex.
- 30 Florida Petroleum Marketers Association (annual meeting), Geo. Washington Hotel, Jacksonville, Fla.

APRIL, 1956

- 2-4 American Institute of Electrical Engrs. (Southwest District No. 7), Dallas, Texas.
- 4-6 American Society of Lubrication Engineers (annual meeting), William Penn Hotel, Pittsburgh, Pa.

8-13 American Chemical Society, Dallas, Texas.

14-18 Petroleum Equipment Suppliers Association of America, Boca Raton Hotel, Boca Raton, Fla.

16-20 Greater New York Safety Council (annual convention and exposition), Statler Hotel, New York, N. Y.

18-20 National Petroleum Association (semiannual meeting), Cleveland Hotel, Cleveland, Ohio.

22-26 National Tank Truck Carriers, Inc., Shoreham Hotel, Washington, D. C.

29-
May 1 Independent Petroleum Association of America (semiannual meeting), Statler Hotel, Los Angeles, Cal.

30-
May 2 Chamber of Commerce of the United States (annual meeting), Washington, D. C.

30-
May 4 American Petroleum Institute (safety and fire protection mid-year meeting), Warwick Hotel, Philadelphia, Pa.

MAY, 1956

13-15 Empire State Petroleum Association, Statler Hotel, Buffalo, N. Y.

13-15 Pennsylvania Petroleum Association, Bedford Springs Hotel, Bedford, Pa.

14-17 American Petroleum Institute (Division of Refining, 21st mid-year meeting), Sheraton Mount Royal Hotel, Montreal, Canada.

21-23 American Petroleum Institute (Division of Marketing, mid-year meeting), Atlanta Biltmore, Atlanta, Ga.

23-26 American Petroleum Institute (Division of Marketing, Lubrication Committee), Broadmoor, Colorado Springs, Colo.

JUNE, 1956

3-8 SAE Summer meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

4-8 National Fire Protection Assn. (60th annual meeting), Statler Hotel, Boston, Mass.

12-13 Petroleum Packaging Committee, Statler Hotel, Boston, Massachusetts.

17-22 ASTM 59th Annual Meeting and 12th Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City, N. J.

21-22 Western Petroleum Refiners Association (regional meeting), Broadview Hotel, Wichita, Kansas.

25-29 American Institute of Electrical Engrs. (1956 Summer & Pacific general), San Francisco, Calif.

SEPTEMBER, 1956

7-8 Desk & Derrick Club, New Orleans, La.

12-14 National Petroleum Association (annual meeting), Traymore Hotel, Atlantic City, N. J.

13-14 Petroleum Packaging Committee, Chicago, Illinois.

16-21 American Chemical Society
(130th annual meeting), Atlan-
tic City, N. J.

16-22 ASTM 2nd Pacific Area Na-
tional Meeting and Apparatus
Exhibit, Hotel Statler, Los An-
geles, Calif.

19-21 National Industrial Conference
Board (marketing meeting)
Waldorf-Astoria Hotel, New
York, N. Y.

20-21 Mid-Continent Oil & Gas Assn.
(membership meeting La.-Ark.
Division), Roosevelt Hotel,
New Orleans, La.

24-25 IOCA Ninth Annual Meeting,
Bismarck Hotel, Chicago, Ill.

OCTOBER, 1956

1-3 Texas Mid-Continent Oil &
Gas Association (annual meet-
ing), Rice Hotel, Houston,
Texas.

1-5 American Institute of Electrical
Engrs. (1956 Fall general),
Morrison Hotel, Chicago, Ill.

14-20 American Petroleum Institute
Oil Progress Week.

17-19 National Industrial Conference
Board (atomic energy meet-
ing), Waldorf-Astoria Hotel,
New York, N. Y.

22-24 NLGI ANNUAL MEETING
Edgewater Beach Hotel, Chi-
cago, Ill.

29-30 Independent Petroleum Asso-
ciation of America (annual
meeting) Statler Hotel, Dallas,
Texas.

NOVEMBER, 1956

1-2 SAE National Diesel Engine
Meeting, Drake Hotel, Chicago,
Ill.

8-9 SAE National Fuels and Lubri-
cants Meeting, The Mayo,
Tulsa, Okla.

12-15 American Petroleum Institute
(36th annual meeting), Conrad
Hilton & Palmer House, Chi-
cago, Ill.

26-30 National Exposition of Power
and Mechanical Engineering
(ASME), New Coliseum, New
York, N. Y.

27-30 American Chemical Society
(9th National Chemical Exposi-
tion), Cleveland, Ohio.

APRIL, 1957

16-18 National Petroleum Associa-
tion, Cleveland, Ohio

JUNE, 1957

16-21 American Society for Testing
Materials, Chalfonte-Haddon
Hall, Atlantic City, N. J.

SEPTEMBER, 1957

11-13 National Petroleum Associa-
tion, Atlantic City, N. J.

OCTOBER, 1957

28-30 NLGI ANNUAL MEETING
Edgewater Beach Hotel, Chi-
cago, Ill.

APRIL, 1958

16-18 National Petroleum Associa-
tion, Cleveland, Ohio

JUNE, 1958

22-28 ASTM 61st Annual Meeting,
Hotel Statler, Boston, Mass.

SEPTEMBER, 1958

10-12 National Petroleum Associa-
tion, Atlantic City, N. J.

OCTOBER, 1958

27-29 NLGI ANNUAL MEETING
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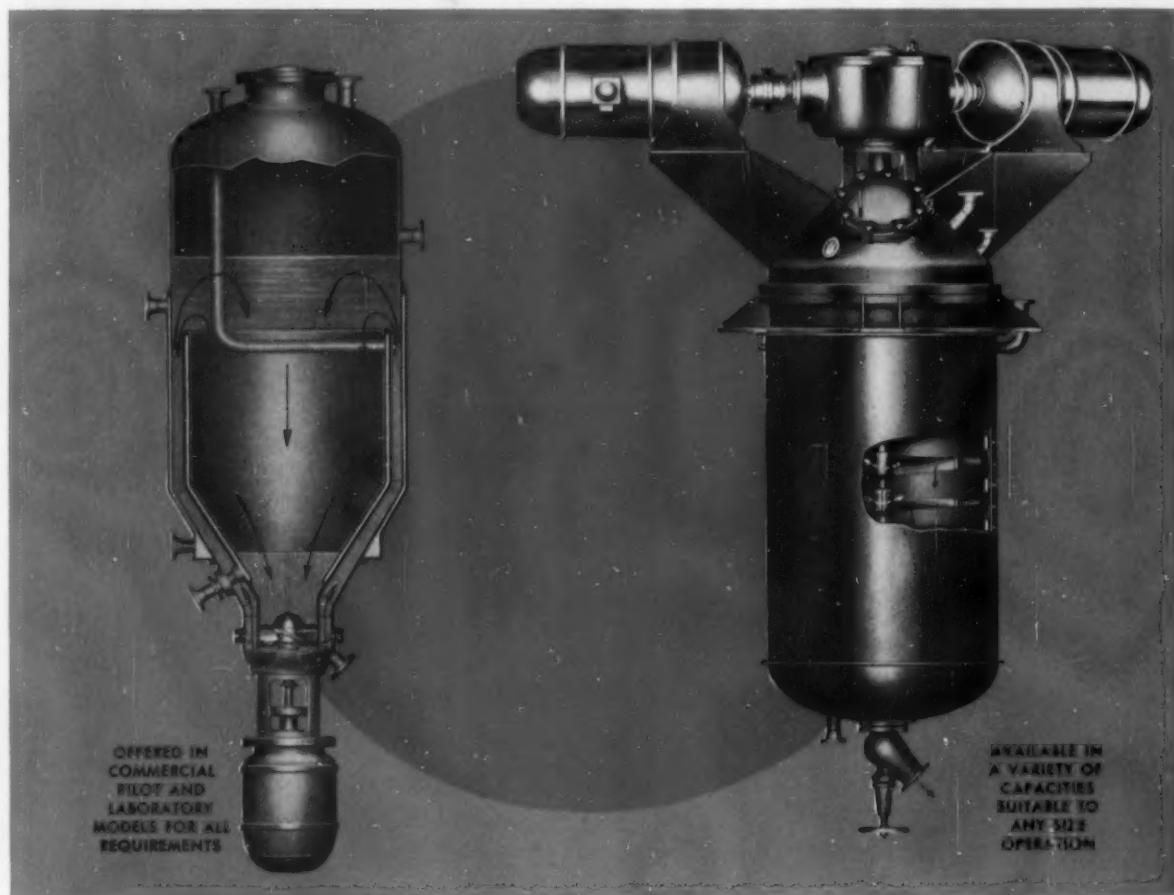
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